US006445683B1

(12) **United States Patent**
Nobuyasu et al.

(10) **Patent No.: US 6,445,683 B1**
(45) **Date of Patent: Sep. 3, 2002**

(54) **HOST SYSTEM FOR BASE STATION**

(75) Inventors: **Kosuke Nobuyasu; Tatsuru Nakagaki**, both of Kawasaki (JP)

(73) Assignee: **Fujitsu Limited**, Kawasaki (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/082,360**

(22) Filed: **May 20, 1998**

(30) **Foreign Application Priority Data**

Nov. 7, 1997 (JP) 9-305328

(51) **Int. Cl.**[7] **H04L 12/28**; H04Q 7/00; H04J 3/24; H04J 3/22

(52) **U.S. Cl.** **370/310.1**; 370/328; 370/395.6

(58) **Field of Search** 370/395–399, 370/468, 310.11, 310.2, 313, 320, 335, 338, 342, 349, 392, 395.1, 395.6, 395.63, 395.65, 393, 473, 474, 328

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,802,051 A	*	9/1998	Petersen et al.	370/473
5,878,045 A	*	3/1999	Timbs	370/328
5,930,265 A	*	7/1999	Duault et al.	370/473
5,953,339 A	*	9/1999	Baldwin et al.	370/397
6,009,096 A	*	12/1999	Jaisingh et al.	370/310.1
6,021,135 A	*	2/2000	Ishihara et al.	370/474
6,151,318 A	*	11/2000	Woodward et al.	370/474

OTHER PUBLICATIONS

Boldt et al, Modeling an ATM based Access network for 3rd generation mobile communication networks, 4/98, IEEE, pp. 2590–2593.*

Xiaoyu et al, QoS Simulation AAL2 in CDMA/ATM based Mobile systems, 9/00, IEEE, pp. 884–887.*

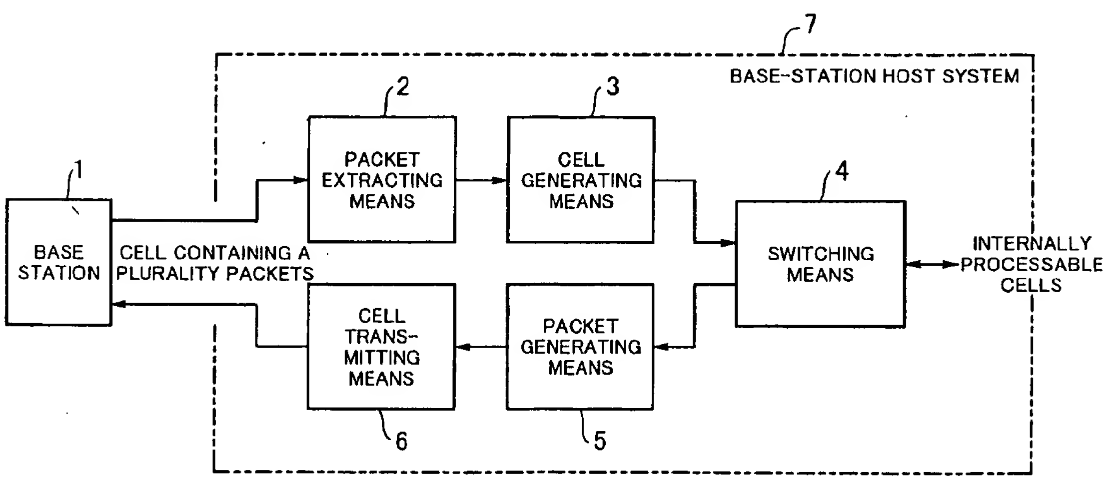
* cited by examiner

Primary Examiner—Chau Nguyen
Assistant Examiner—Chiho A. Lee
(74) *Attorney, Agent, or Firm*—Katten Muchin Zavis Rosenman

(57) **ABSTRACT**

A base-station host system achieves high-speed routing to reduce a burden on a controller which carries out a routing process, and receives a cell containing a plurality of packets (an ATM cell of AAL Type 2) from a base station. A cell containing a plurality of packets is transmitted from the base station to the base-station host system. A packet extracting unit extracts the packets from the received cell. A cell generating unit generates an internally processable cell based on information carried by the payload of a packet. A switch unit switches internally processable cells depending on routes thereof. For reverse communications, internally processable cells are sent from the switch unit to a packet generating unit. The packet generating unit generates packets based on information carried by the payloads of the internally processable cells. A cell transmitting unit collects a plurality of packets designed for the same base station, generates a cell containing those packets, and transmits the generated cell to the base station.

6 Claims, 11 Drawing Sheets



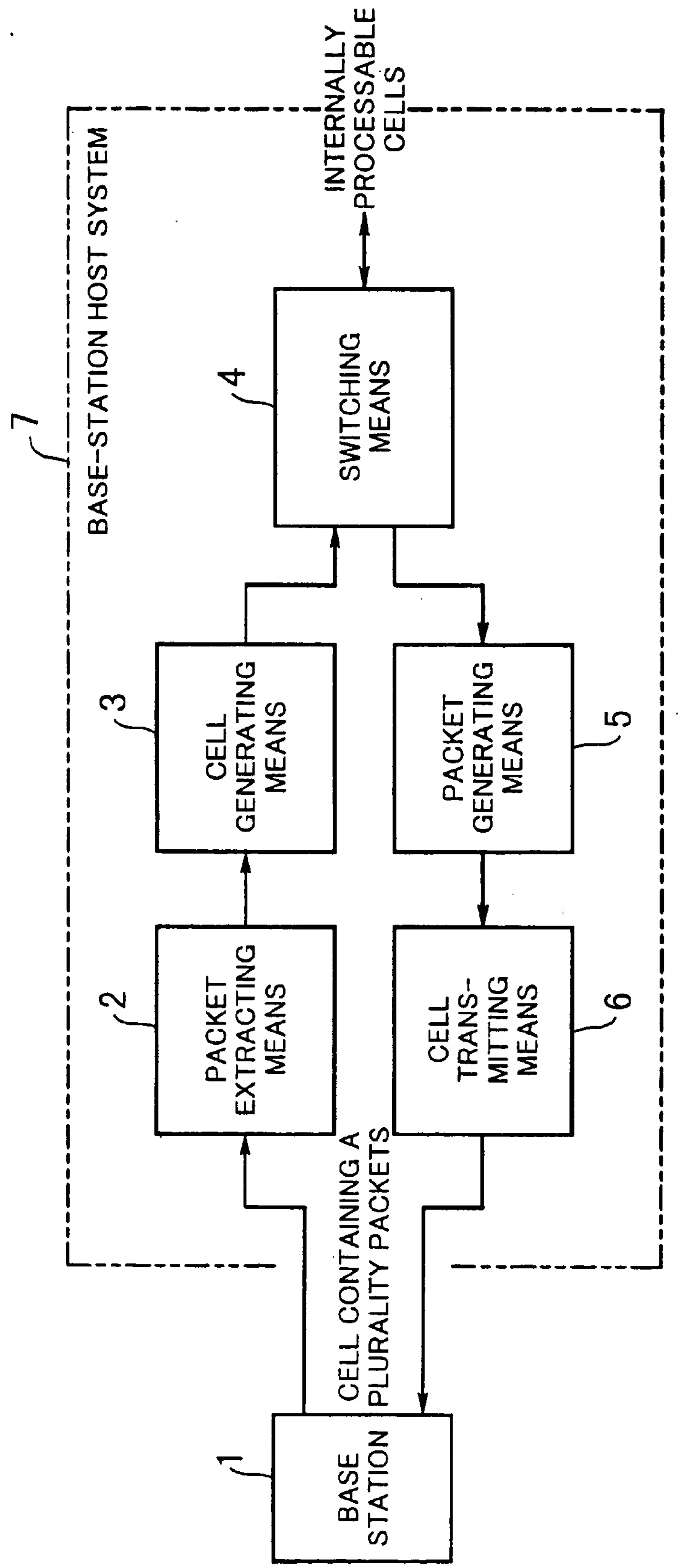

BASE-STATION HOST SYSTEM
7
INTERNALLY PROCESSABLE CELLS
SWITCHING MEANS
4
CELL GENERATING MEANS
3
PACKET GENERATING MEANS
5
PACKET EXTRACTING MEANS
2
CELL TRANS-MITTING MEANS
6
CELL CONTAINING A PLURALITY PACKETS
BASE STATION
1

FIG. 1

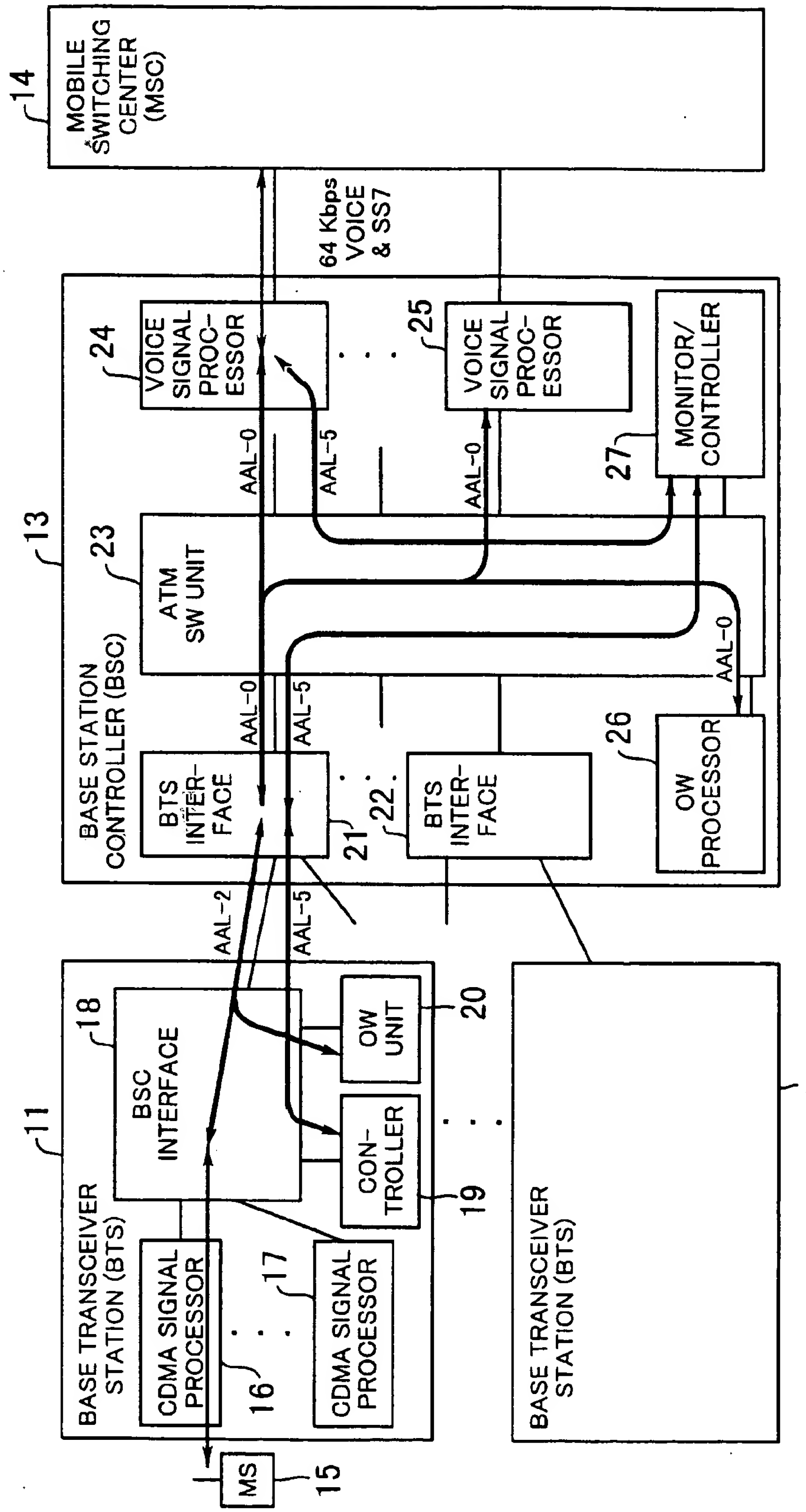

14
MOBILE SWITCHING CENTER (MSC)
64 Kbps VOICE & SS7
13
BASE STATION CONTROLLER (BSC)
24
VOICE SIGNAL PROC-ESSOR
25
VOICE SIGNAL PROC-ESSOR
27
MONITOR/ CONTROLLER
23
ATM SW UNIT
AAL-0
AAL-5
AAL-0
AAL-0
AAL-0
AAL-5
BTS INTER-FACE
21
22
BTS INTER-FACE
26
OW PROCESSOR
AAL-2
AAL-5
11
BASE TRANSCEIVER STATION (BTS)
18
BSC INTERFACE
OW UNIT
20
CON-TROLLER
19
CDMA SIGNAL PROCESSOR
16
17
CDMA SIGNAL PROCESSOR
MS
15
BASE TRANSCEIVER STATION (BTS)
12

FIG. 2

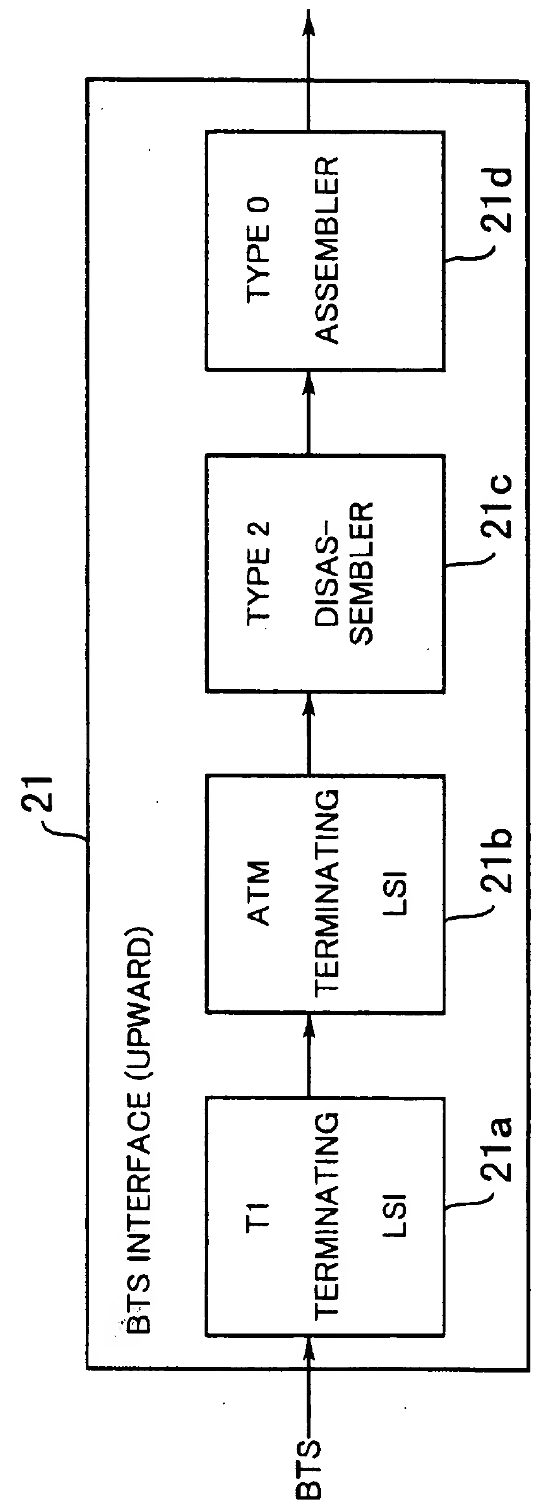

BTS INTERFACE (UPWARD)
21
BTS
T1 TERMINATING LSI
21a
ATM TERMINATING LSI
21b
TYPE 2 DISAS-SEMBLER
21c
TYPE 0 ASSEMBLER
21d

FIG. 3

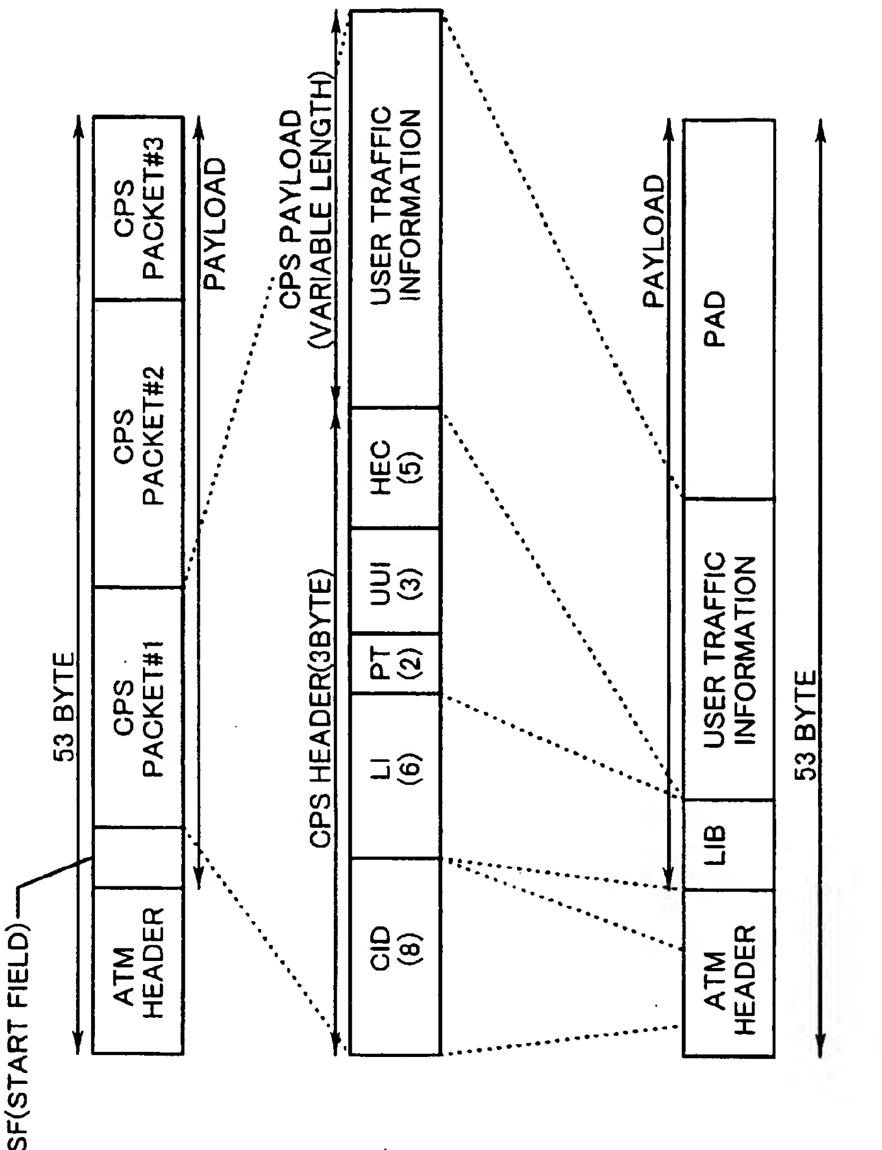


FIG. 4(A) AAL-TYPE 2 ATM CELL

FIG. 4(B) CPS PACKET

FIG. 4(C) AAL-TYPE 0 ATM CELL

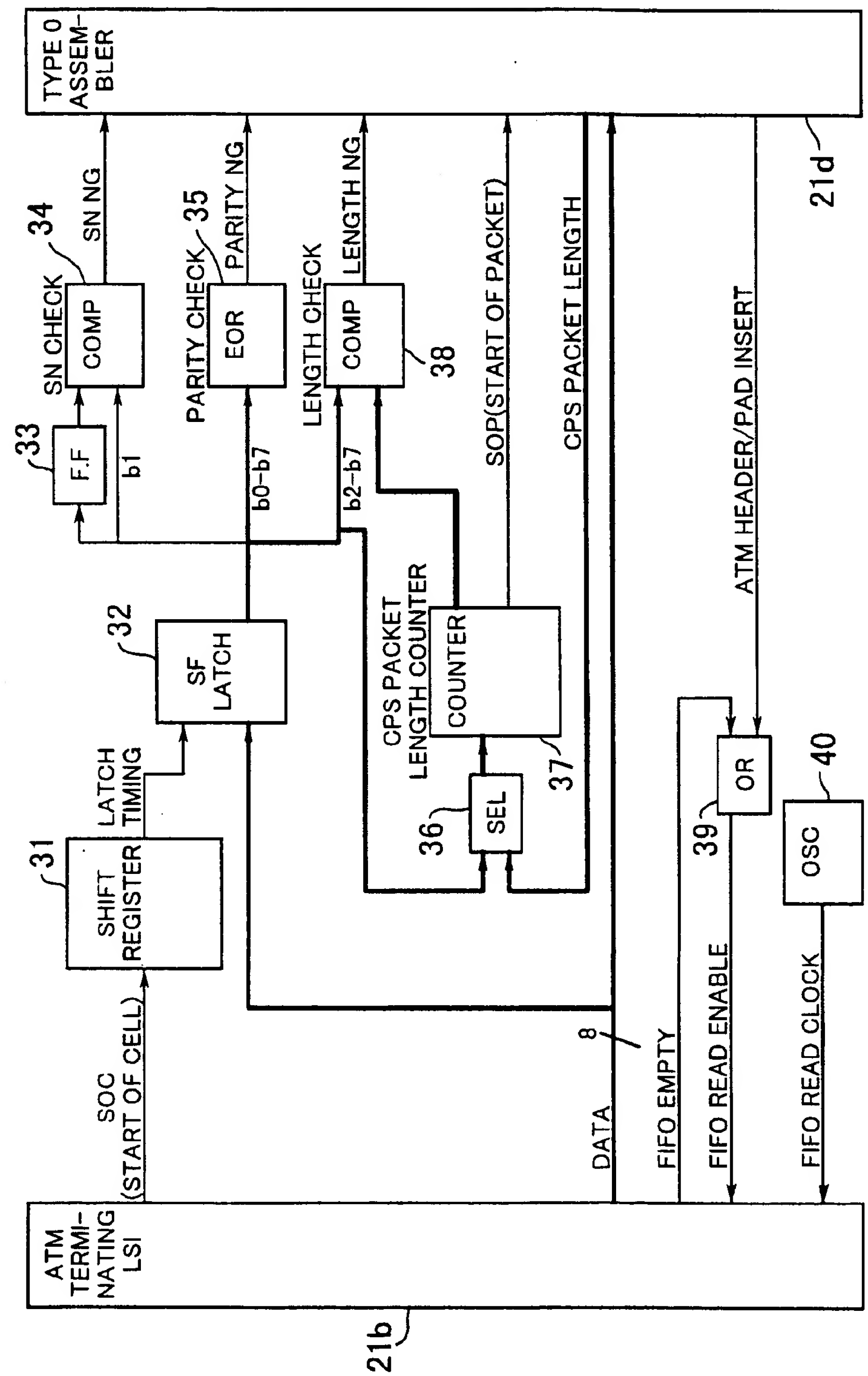

TYPE 0 ASSEM-BLER
21d
SN CHECK
COMP
34
SN NG
PARITY CHECK
EOR
35
PARITY NG
LENGTH CHECK
COMP
38
LENGTH NG
SOP(START OF PACKET)
CPS PACKET LENGTH
ATM HEADER/PAD INSERT
33
F.F
b1
b0-b7
b2-b7
32
SF LATCH
CPS PACKET LENGTH COUNTER
COUNTER
37
LATCH TIMING
31
SHIFT REGISTER
36
SEL
39
OR
40
OSC
SOC (START OF CELL)
DATA
8
FIFO EMPTY
FIFO READ ENABLE
FIFO READ CLOCK
ATM TERMI-NATING LSI
21b

FIG. 5

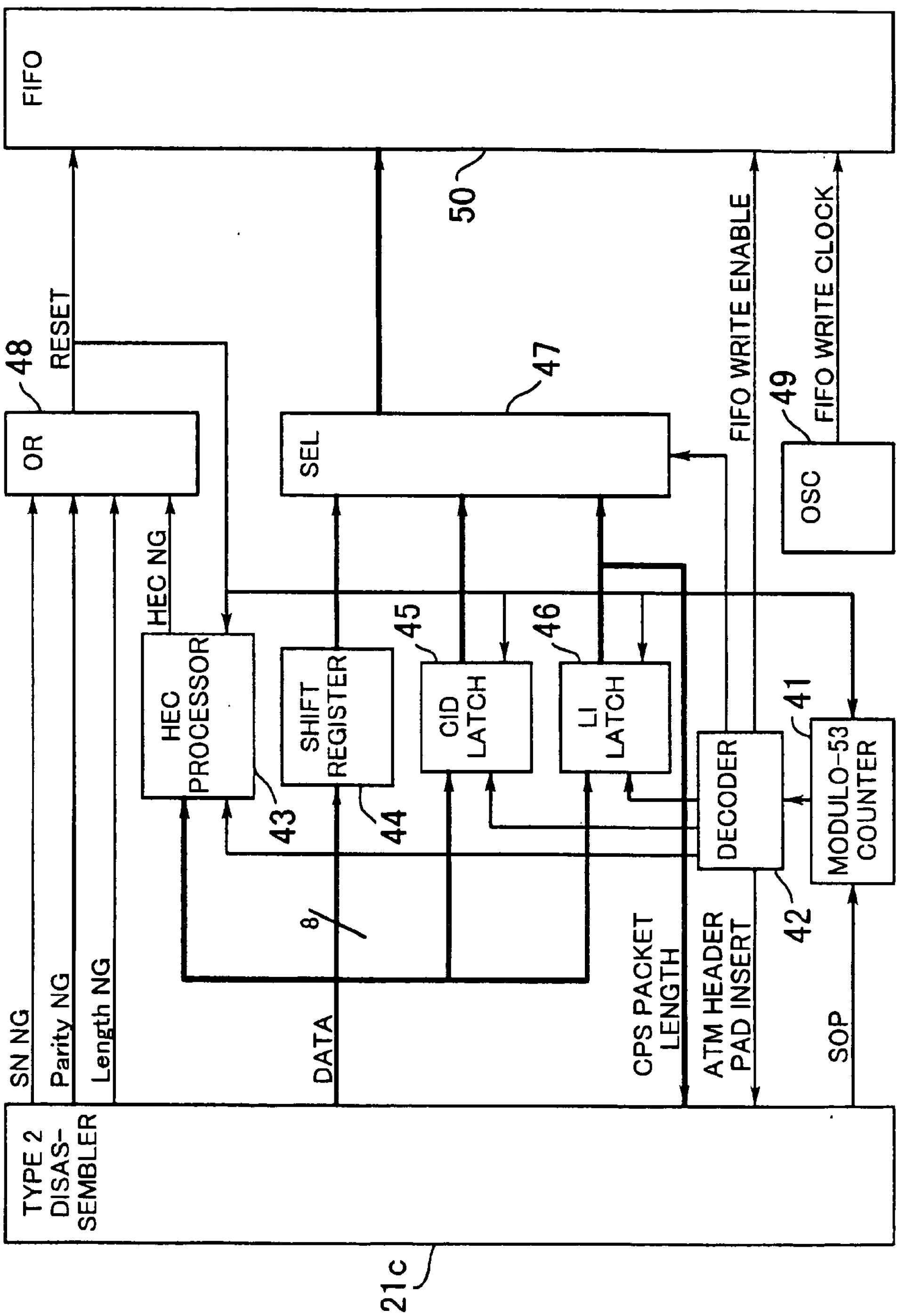

FIFO
50
OR
48
RESET
SEL
47
FIFO WRITE ENABLE
FIFO WRITE CLOCK
49
OSC
HEC NG
HEC PROCESSOR
43
SHIFT REGISTER
44
CID LATCH
45
LI LATCH
46
DECODER
42
MODULO-53 COUNTER
41
8
SN NG
Parity NG
Length NG
DATA
CPS PACKET LENGTH
ATM HEADER PAD INSERT
SOP
TYPE 2 DISAS-SEMBLER
21c

FIG. 6

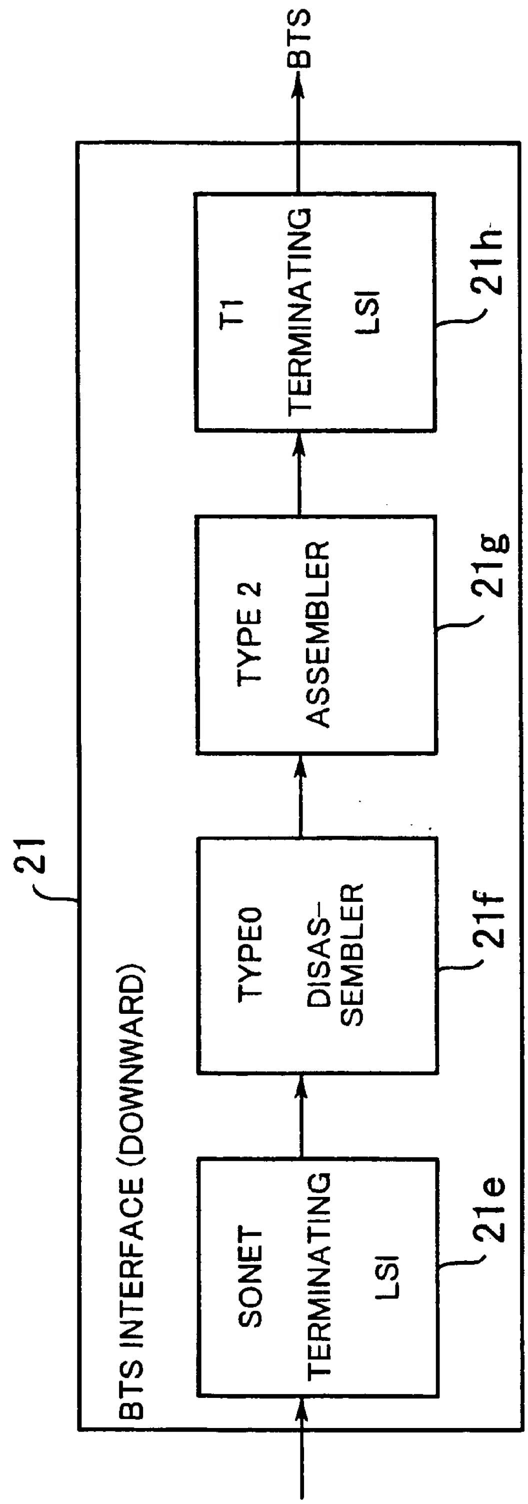

BTS
21
BTS INTERFACE (DOWNWARD)
SONET
TERMINATING
LSI
21e
TYPE0
DISAS-
SEMBLER
21f
TYPE 2
ASSEMBLER
21g
T1
TERMINATING
LSI
21h

FIG. 7

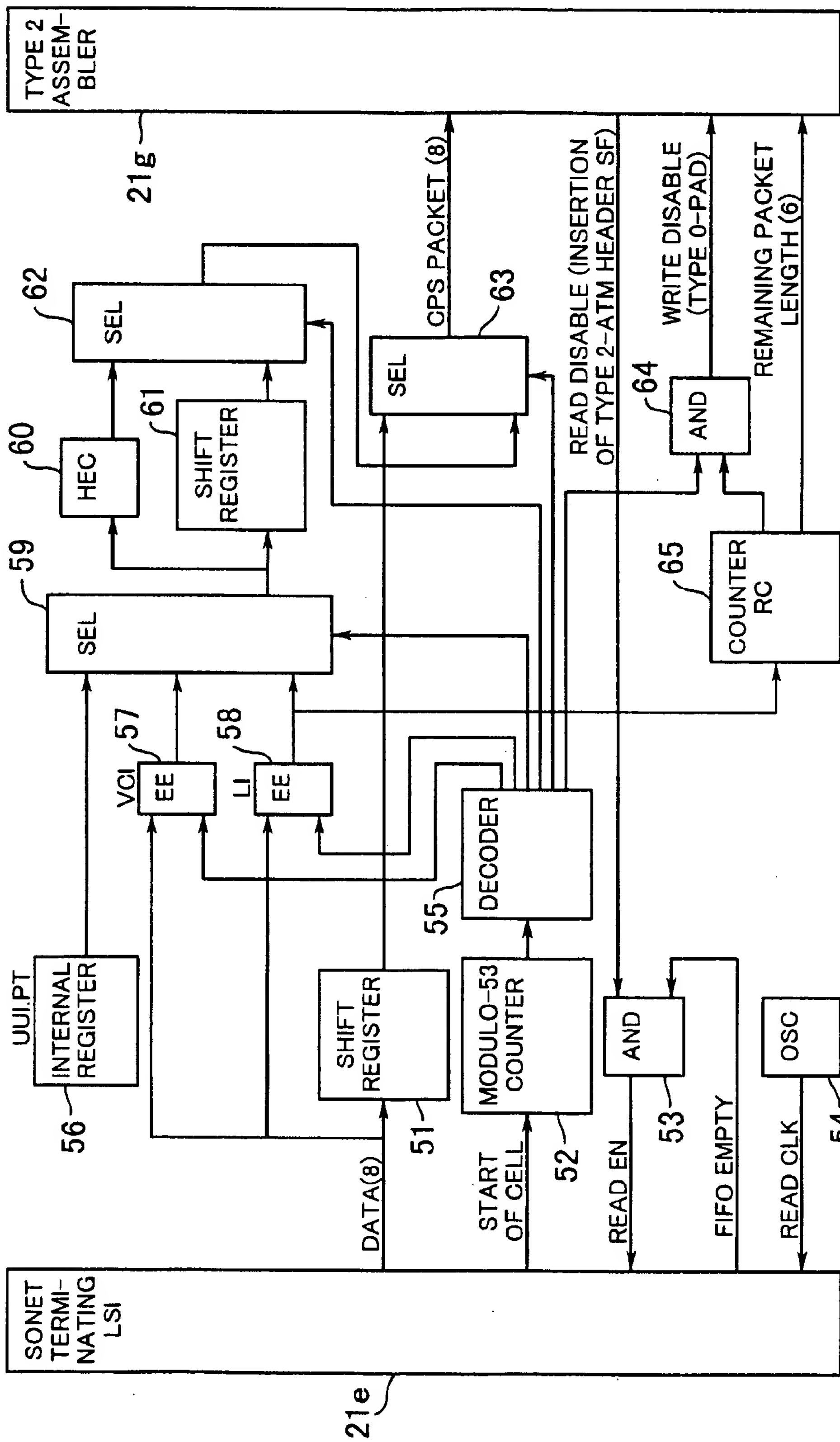
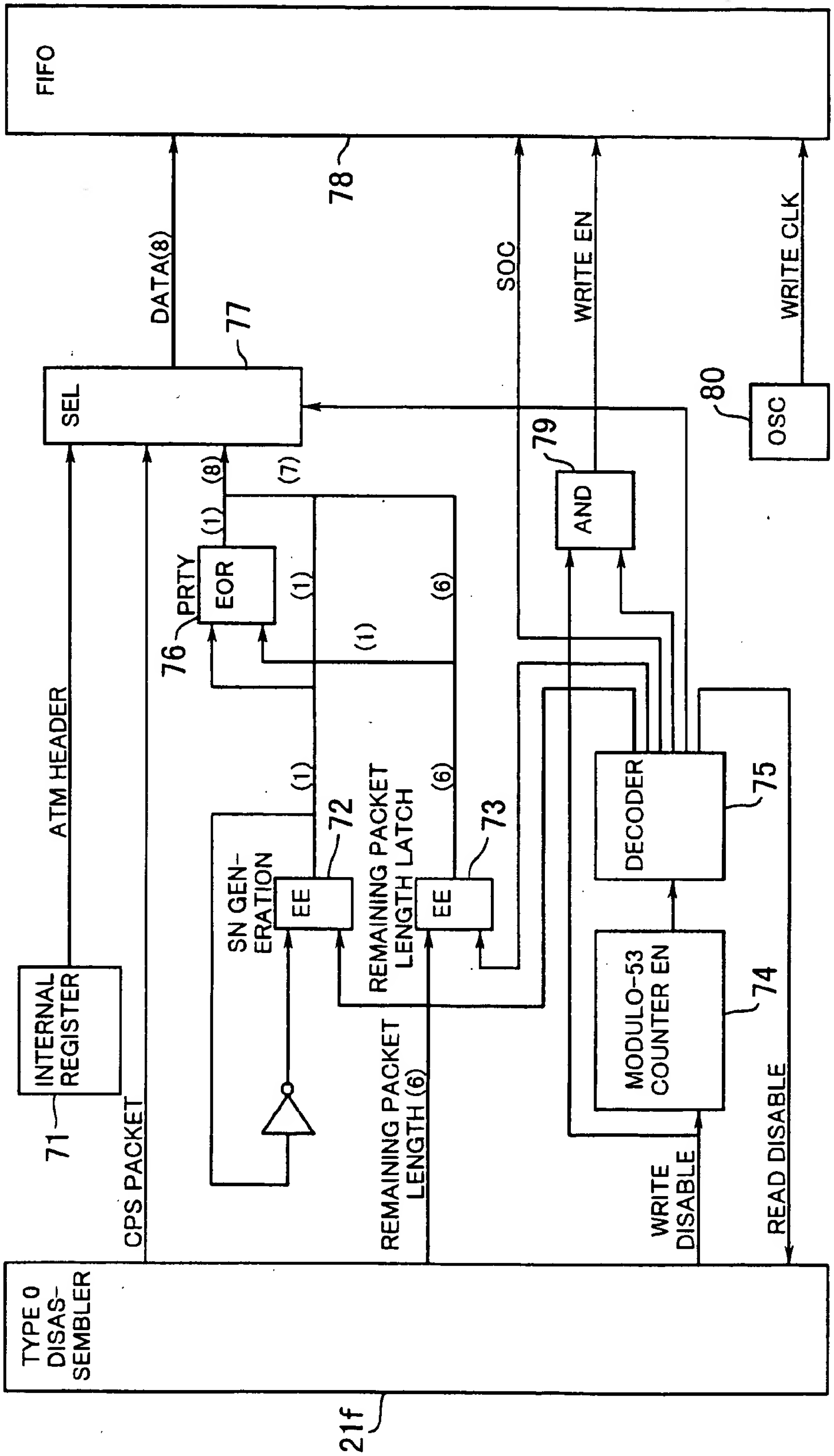

TYPE 2 ASSEM-BLER
21g
CPS PACKET (8)
READ DISABLE (INSERTION OF TYPE 2-ATM HEADER SF)
WRITE DISABLE (TYPE 0-PAD)
REMAINING PACKET LENGTH (6)
62
SEL
63
SEL
60
HEC
61
SHIFT REGISTER
64
AND
59
SEL
65
COUNTER RC
VCI
57
EE
LI
58
EE
DECODER
55
UUI.PT
INTERNAL REGISTER
56
SHIFT REGISTER
51
MODULO-53 COUNTER
52
AND
53
OSC
54
DATA(8)
START OF CELL
READ EN
FIFO EMPTY
READ CLK
SONET TERMI-NATING LSI
21e

FIG. 8



FIFO
78
DATA(8)
SOC
WRITE EN
WRITE CLK
77
SEL
80
OSC
79
AND
(8)
(1)
(7)
PRTY
EOR
76
(1)
(6)
(1)
ATM HEADER
DECODER
75
(1)
(6)
72
73
SN GEN-
ERATION
EE
REMAINING PACKET
LENGTH LATCH
EE
INTERNAL
REGISTER
71
MODULO-53
COUNTER EN
74
CPS PACKET
REMAINING PACKET
LENGTH (6)
WRITE
DISABLE
READ DISABLE
TYPE 0
DISAS-
SEMBLER
21f

FIG. 9

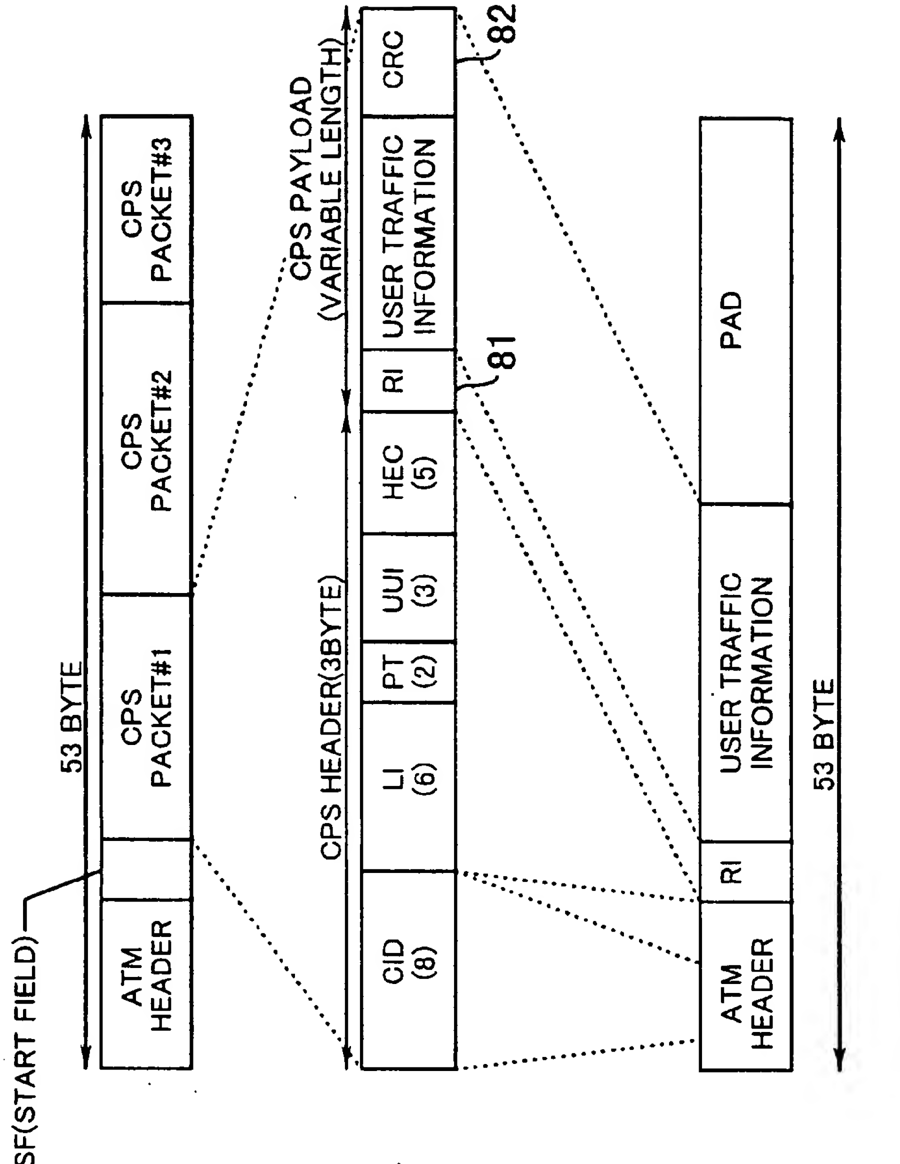


FIG. 10(A) AAL-TYPE 2 ATM CELL

FIG. 10(B) CPS PACKET

FIG. 10(C) AAL-TYPE 0 ATM CELL

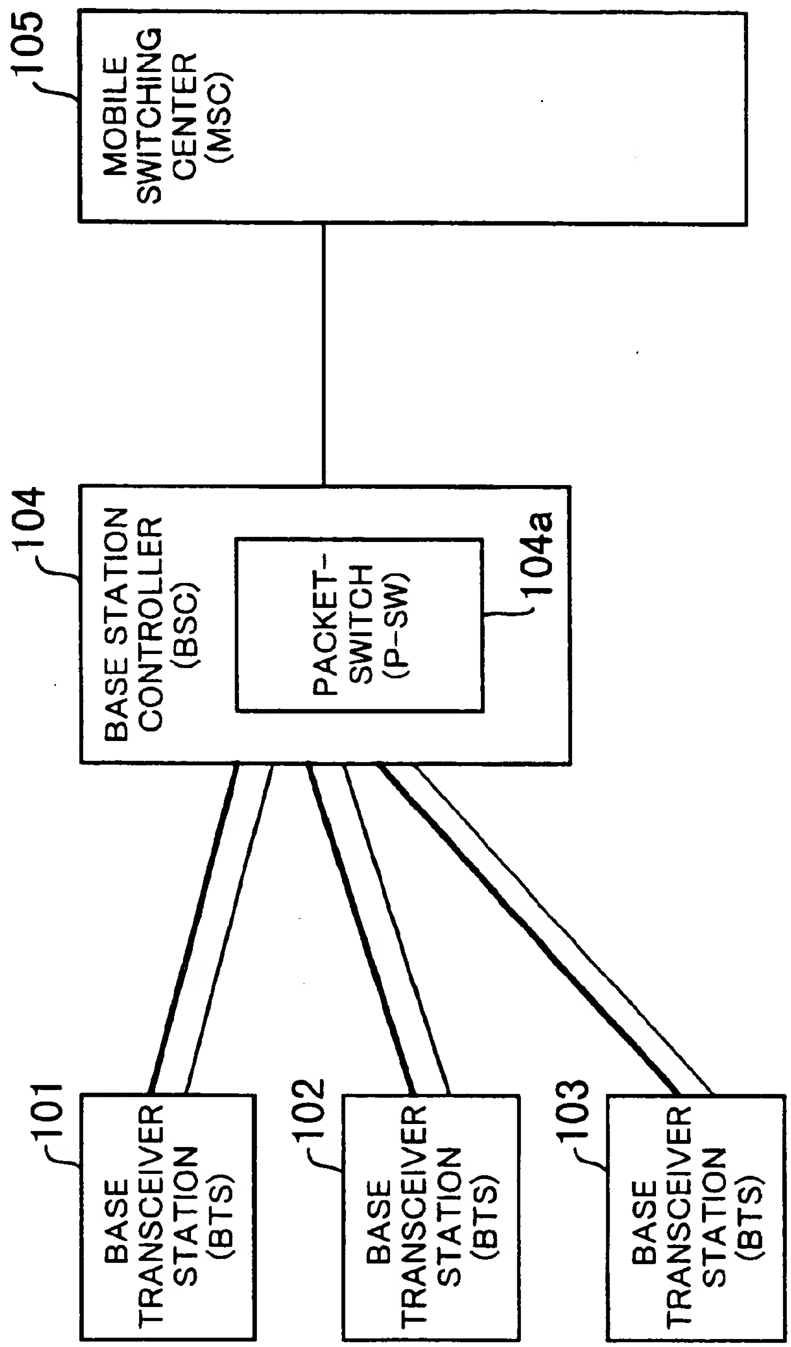

105
MOBILE SWITCHING CENTER (MSC)
104
BASE STATION CONTROLLER (BSC)
104a
PACKET-SWITCH (P-SW)
101
BASE TRANSCEIVER STATION (BTS)
102
BASE TRANSCEIVER STATION (BTS)
103
BASE TRANSCEIVER STATION (BTS)

FIG. 11

HOST SYSTEM FOR BASE STATION

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to a host system for a base station, and more particularly to a basestation host system for receiving ATM (Asynchronous Transfer Mode) cells of AAL (ATM Adaptation Layer) Type 2 from a base station.

(2) Description of the Related Art

Since ATM networks transfer all information as cells, layers (up to the ATM layer) involved in the transfer of cells do not process voice data, video data, and other data in consideration of media and services. Service qualities (delay times, error rates, etc.) required for respective services are different from each other. Therefore, for converting original information for the services into cells, it is necessary to absorb the difference between such different service qualities. ATM adaptation layers (AALs) are employed to meet such a requirement.

There are different types of ATM adaptation layers that are classified according to function. Recently, AAL Type 2 has been standardized. Efforts have been made to standardize AAL Type 2 for transferring voice data that have been compressed to less than 64Kbps. AAL Type 2 has been developed under the concept of multiplexing CPS (Common Part Sublayer) packets of plural users having short variable-length payloads into ATM cells.

AAL Type 2 serves to meet the strong demand in the market for applying the ATM technology to communications between radio base stations and switching offices of cellular mobile communication systems.

Inasmuch as the standardization of ATM communications of AAL Type 2 has just been completed, there has heretofore been available no system based on AAL Type 2.

FIG. 11 of the accompanying drawings shows in block form a mobile communication system to which ATM communications of AAL Type 2 are applied. As shown in FIG. 11, the mobile communication system has a plurality of base transceiver stations (BTS) 101–103 and a base station controller (BSC) 104. ATM communications of AAL Type 2 are applied to the transmission over entrance links between the base transceiver stations 101–103 and the base station controller 104. In the base station controller 104, CPS packets contained in ATM cells of AAL Type 2 are extracted, and routed using a packet switch (P-SW) 104*a*.

The packet switch 104*a* buffers each packet, reads its address, and effects switching depending on the address. Such activities of the packet switch 104*a* are software-implemented. However, the software-based packet routing is slow and tends to put a large burden on the base station controller 104 which controls the packet switch 104*a*.

For transmitting order wire service information, it is necessary to install separate dedicated lines between base transceiver stations 101–103 and the base station controller 104. However, since installing such separate dedicated lines entails an additional expenditure of expenses, there is a demand for an improved scheme for transmitting order wire service information without separate dedicated lines.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a base-station host system for achieving high-speed routing for ATM communications of AAL Type 2 to reduce a burden on a controller which carries out a routing process.

Another object of the present invention is to provide a base-station host system which is capable of transmitting order wire service information without separate dedicated lines.

To accomplish the above objects, there is provided a host system for controlling a base station to transmit a signal to and receive a signal from the base station by way of a cell containing a plurality of packets representing signals from the base station to a plurality of base station or from a plurality of base station to the base station, comprising packet extracting means for extracting a plurality of individual packets contained in a cell, cell generating means for generating an internally processable cell based on the individual packets extracted by the packet extracting means, switching means for switching internally processable cells generated by the cell generating means depending on routes thereof, packet generating means for generating packets based on an internally processable cell destined for a base station, and cell transmitting means for generating a cell containing a plurality of packets designed to the same base station from the packets which are generated by the packet generating means and transmitting the generated cell to the base station.

To accomplish the above objects, there is also provided a host system for controlling a plurality of base stations in a mobile communication system, comprising receiving means for receiving a cell carrying order wire service information from a base station, and transmitting means for adding order wire service information to a cell and transmitting the cell to a base station.

The above and other objects, features, and advantages of the present invention will become apparent from the following description when taken in conjunction with the accompanying drawings which illustrate preferred embodiments of the present invention by way of example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram illustrating the principles of the present invention;

FIG. 2 is a block diagram of a communication system which incorporates a base-station host system according to a first embodiment of the present invention;

FIG. 3 is a block diagram of an upward processing section of a BTS interface of the base-station host system;

FIG. 4(A) is a diagram showing the structure of an ATM cell of AAL Type 2;

FIG. 4(B) is a diagram showing the structure of a CPS packet;

FIG. 4(C) is a diagram showing the structure of an ATM cell of AAL Type 0;

FIG. 5 is a block diagram of a Type 2 disassembler;

FIG. 6 is a block diagram of a Type 0 assembler;

FIG. 7 is a block diagram of a downward processing section of the BTS interface of the base-station host system;

FIG. 8 is a block diagram of a Type 0 disassembler;

FIG. 9 is a block diagram of a Type 2 assembler;

FIG. 10(A) is a diagram showing the structure of an ATM cell of AAL Type 2 in a base-station host system according to a second embodiment of the present invention;

FIG. 10(B) is a diagram showing the structure of a CPS packet in the base-station host system according to the second embodiment of the present invention;

FIG. 10(C) is a diagram showing the structure of an ATM cell of AAL Type 0 in the base-station host system according to the second embodiment of the present invention; and

FIG. 11 is a block diagram of a mobile communication system to which ATM communications of AAL Type 2 are applied.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The principles of the present invention will first be described below with reference to FIG. 1. As shown in FIG. 1, a base-station host system 7 according to the present invention comprises a packet extracting means 2 for extracting a plurality of individual packets contained in a cell, a cell generating means 3 for generating an internally processable cell based on the individual packets extracted by the packet extracting means 2, a switching means 4 for switching internally processable cells generated by the cell generating means 3 depending on their routes, a packet generating means 5 for generating packets based on an internally processable cell destined for a base station 1, and a cell transmitting means 6 for generating a cell containing a plurality of packets destined to the same base station from the packets which are generated by the packet generating means 5 and transmitting the generated cell to the base station.

The payload of each of the packets extracted by the packet extracting means 2 carries at least user traffic information, and the payload of an internally processable cell based on which packets are generated by the packet generating means 5 also carries at least user traffic information.

The base-station host system shown in FIG. 1 operates as follows: A cell containing a plurality of packets is transmitted from the base station 1 to the base-station host system 7. The packet extracting means 2 extracts a plurality of packets contained in the cell which is received.

Since the payload of each of the extracted packets carries user traffic information, the cell generating means 3 generates an internally processable cell based on the information carried by the payload of one packet. The generated internally processable cell can be routed by the switching means 4 because it is destined for a single user.

Internally processable cells generated by the cell generating means 3 are sent to the switching means 4, which switches the internally processable cells depending on their routes. Generally, the switching means 4 first effects a software-depending process for setting up routes in a routing table (present in a register) and subsequently effects a hardware-depending process for routing cells. Therefore, the switching means 4 has a high routing rate and suffers a relatively low burden for routing control.

For reverse communications from the base-station host system 7 to the base station 1, an internally processable cell is transmitted from the switching means 4 to the packet generating means 5. The internally processable cell carries at least the user traffic information set from a single user. The packet generating means 5 generates packets based on the information carried by the payload of the internally processable cell. The cell transmitting means 6 collects packets destined for the same base station from those packets which are generated by the packet generating means 5, generates a cell containing the collected packets, and transmits the generated cell to the base station 1.

Therefore, high-speed routing can be accomplished and a burden on a controller for routing cells can be reduced for ATM communications.

The payload of each of the packets extracted by the packet extracting means 2 carries order wire service information, and the payload of an internally processable cell based on which packets are generated by the packet generating means 5 also carries order wire service information.

Consequently, order wire service information can be transmitted without the installation of separate dedicated lines.

The host system for controlling a base station and the host system for controlling a plurality of base stations specifically represent a base station controller (BSC) or a mobile switching center (MSC) having basestation controlling functions, respectively.

A base-station host system according to a first embodiment of the present invention will be described below. According to the first embodiment, a cell containing a plurality of packets, as referred to above, corresponds to an ATM cell of AAL Type 2, and an internally processable cell, as referred to above, corresponds to an ATM cell of AAL Type 0.

FIG. 2 shows in block form a communication system which incorporates the base-station host system according to the first embodiment of the present invention. As shown in FIG. 2, the communication system basically comprises a plurality of base transceiver stations (BTS) 11, 12, a base station controller (BSC) 13, a mobile switching center (MSC) 14, and a mobile station (MS) 15. Actually, the communication system has about 150 base transceiver stations 11, 12, which are connected to the single base station controller 13. While only one mobile station (MS) 15 is shown in FIG. 2, the communication system has many mobile stations that are connected to the base transceiver stations 11, 12 by radio links.

User traffic information, signaling information, order wire service information, and BTS monitoring control information are transmitted over entrance links between the base transceiver stations 11, 12 and the base station controller 13. The user traffic information and the signaling information as they are put together by CDMA (Code Division Multiple Access) signal processing are transmitted by ATM cells of AAL Type 2. The order wire service information is also transmitted by ATM cells of AAL Type 2. The BTS monitoring control information is transmitted by ATM cells of AAL Type 5.

Voice signals of 64 Kbps and control signals according to the signaling system #7 (SS7) are transmitted between the base station controller 13 and the mobile switching center 14.

In FIG. 2, thinner lines interconnecting the blocks represent actual physical links, and thicker lines transmission paths for signals that flow through the physical links.

The base transceiver station 11 comprises a plurality of CDMA signal processors 16, 17, a BSC interface 18, a controller 19, and an OW unit 20. The CDMA signal processors 16, 17 processes user traffic information and signaling information according to the CDMA signal processing, and transmit the processed information to the mobile station 15. The CDMA signal processors 16, 17 also process a signal transmitted from the mobile station 15 according to the CDMA signal processing to obtain user traffic information and signaling information, and transmit the user traffic information and the signaling information together through the BSC interface 18 to the basestation host system 13. The controller 19 monitors the base transceiver station 11 and transmits monitor information BTS monitoring control information through the BSC interface 18 to the base-station host system 13. The controller 19 also controls the base transceiver station 11 according to control information which has been sent as BTS monitoring control information from the basestation host system 13. The OW unit 20 transmits order wire service information to and receives order wire service information from the base-station host system 13 through the BSC interface 18.

The BSC interface 18 adds the user traffic information and the signaling information sent from the CDMA signal pro-

cessors **16**, **17** to an ATM cell of AAL Type 2, and transmits the ATM cell of AAL Type 2 to the base-station host system **13**. Similarly, the BSC interface **18** adds order wire service information sent from the OW unit **20** to an ATM cell of AAL Type 2, and transmits the ATM cell of AAL Type 2 to the base-station host system **13**. Furthermore, the BSC interface **18** adds the BTS monitoring control information sent from the controller **19** to an ATM cell of AAL Type 5, and transmits the ATM cell of AAL Type 5 to the base-station host system **13**. The BSC interface **18** also reverses the above adding and transmitting process.

The base transceiver station **12** is of the same structure and operates in the same manner as the base transceiver station **11**.

The base-station host system **13** comprises a plurality of BTS interfaces **21**, **22**, an ATM SW (switch) unit **23**, a plurality of voice signal processors **24**, **25**, an OW processor **26**, and a monitor/controller **27**. Each of the BTS interfaces **21**, **22** effects a different operation depending on the type of an ATM cell transmitted from the BSC interfaces of the base transceiver stations **11**, **12**. Specifically, if an ATM cell of AAL Type 2 is transmitted, then each of the BTS interfaces **21**, **22** converts the ATM cell of AAL Type 2 into an ATM cell of AAL Type 0, and transmits the ATM cell of AAL Type 0 to the ATM SW unit **23**. The ATM SW unit **23** transmits an ATM cell which carries user traffic information and order wire service information to the voice signal processors **24**, **25**, and transmits an ATM cell which carries order wire service information to the OW processor **26**. If an ATM cell of AAL Type 5 is transmitted, then each of the BTS interfaces **21**, **22** transmits the ATM cell of AAL Type 5 as it is through the ATM SW unit **23** to the monitor/controller **27**. The BTS interfaces **21**, **22** and the ATM SW unit **23** also reverse the above converting and transmitting process.

An ATM cell of AAL Type 0 contains a single item of user traffic information on the payload thereof, and is routed only in an ATM layer without involving an ATM adaptation layer.

The BSC interfaces **18** of the base transceiver stations **11**, **12** are connected to each of the BTS interfaces **21**, **22**, which effects processing operation individually with respect to each of the BSC interfaces **18**.

The ATM SW unit **23** routes a received ATM cell of AAL Type 0 or AAL Type 5 based on a VPI/VCI (Virtual Path Identifier/Virtual Channel Identifier) contained in the header thereof. The ATM SW unit **23** first effects a software-depending process for setting up routes in a routing table (present in a register) and subsequently effects a hardware-depending process for routing cells. Therefore, the ATM SW unit **23** has a high routing rate and suffers a relatively low burden for routing control.

Upon reception of an ATM cell of AAL Type 0, each of the voice signal processors **24**, **25** separates the signaling information from user traffic and signaling information carried by the payload of the received ATM cell, adds the separated signaling information to an ATM cell of AAL Type 5, and transmits the ATM cell of AAL Type 5 through the ATM SW unit **23** to the monitor/controller **27**. Each of the voice signal processors **24**, **25** also separates the user traffic information (actually voice signal) from the ATM cell, decodes the user traffic information according to a QCELP (Qualcomm Code-book Excited Linear Prediction) process, and transmits the decoded user traffic information to the mobile switching center **14**. Each of the voice signal processors **24**, **25** also reverses the above process.

When the OW processor **26** receives an ATM cell of AAL Type 0, the OW processor **26** reads order wire service information carried by the payload of the received ATM cell. The OW processor **26** also reverses the above process.

When the monitor/controller **27** receives an ATM cell of AAL Type 5 transmitted from the controllers **19** of the base transceiver stations **11**, **12**, the monitor/controller **27** reads BTS monitoring control information carried by the payload of the received ATM cell, and carries out a monitoring process based on the monitoring information contained in the BTS monitoring control information. The monitor/controller **27** also adds control information as BTS monitoring control information to an ATM cell of AAL Type 5, and transmits the ATM cell of AAL Type 5 through the ATM SW unit **23** and the BTS interface **21** to either one of the controllers **19** of the base transceiver stations **11**, **12**. Furthermore, when the monitor/controller **27** receives an ATM cell of AAL Type 5 transmitted from the voice signal processors **24**, **25**, the monitor/controller **27** reads signaling information carried by the payload of the received ATM cell, and effects a signaling process on the voice signal processors **24**, **25**.

FIG. **3** shows in block form an upward processing section of each of the BTS interfaces **21**, **22** of the base-station host system **13**. Since the BTS interfaces **21**, **22** are structurally identical to each other, the structure of the upward processing section of the BTS interface **21** will be described below.

The upward processing section of the BTS interface **21** comprises a T1 terminating LSI **21***a*, an ATM terminating LSI **21***b*, a Type 2 disassembler **21***c*, and a Type 0 assembler **21***d*. The T1 terminating LSI **21***a* is supplied with an ATM cell of AAL Type 2 or AAL Type 5 which has been mapped onto a T1 frame. The terminating LSI **21***a* electrically terminates a T1 interface, extracts a clock signal, establishes T1 frame synchronization, and detects an alarm on the T1 frame. The ATM terminating LSI **21***b* extracts an ATM cell from the payload of the T1 frame, checks the extracted ATM cell for an HEC (Header Error Control) error, and filters the received cell according to a VPI/VCI value. The ATM terminating LSI **21***b* also distinguishes between ATM cells of AAL Type 2 and ATM cells of AAL Type 5, sends ATM cells of AAL Type 2 to the Type 2 disassembler **21***c*, and outputs ATM cells of AAL Type 5 to the ATM SW unit **23**.

The Type 2 disassembler **21***c* carries out a preparatory process in preparation for dissembling a plurality of CPS packets contained in an ATM cell of AAL Type 2. Details of the Type 2 disassembler **21***c* will be described later on with reference to FIG. **5**.

The Type 0 assembler **21***d* processes each CPS packet, and assembles an ATM cell of AAL Type 0 based on one CPS packet. Details of the Type 0 assembler **21***d* will be described later on with reference to FIG. **6**.

FIGS. **4**(A), **4**(B), and **4**(C) show the mutual relationship of an ATM cell of AAL Type 2, a CPS packet, and an ATM cell of AAL Type 0.

FIG. **4**(A) shows the structure of an ATM cell of AAL Type 2. As shown in FIG. **4**(A), the ATM cell of AAL Type 2 comprises a header of five bytes and a payload of 48 bytes. The payload includes an SF (Start Field) of one byte at its start and a plurality of CPS packets mapped thereonto after the start field. The start field comprises a 0th bit representing odd parity of the start field, a first bit representing an SN (Sequence Number) which is either "1" or "0", and second through seventh bits representing an OSF (Offset Field) that records a value indicative of the start position of the first CPS packet.

FIG. **4**(B) shows the structure of a CPS packet. As shown in FIG. **4**(B), the CPS packet comprises a header of three

bytes and a variable-length payload. The header comprises a CID (Channel Identifier), an LI (Length Identifier) indicative of the length of the payload of its own packet, a PT (Payload Type) indicative of the type of the payload, a UUI (User-to-User Indication) for the transmission of information between users, and an HEC (Header Error Control) for detecting a header error, which are all mapped thereonto. The variable-length payload comprises user traffic information mapped thereonto.

FIG. 4(C) shows the structure of an ATM cell of AAL Type 0. As shown in FIG. 4(C), the ATM cell of AAL Type 0 comprises a header of five bytes and a payload of 48 bytes. The payload has, at its start, an effective data LIB (Length Indicator B) of one byte indicative of the length of its own user traffic information, and also includes user traffic information mapped thereonto after the LIB and a pad of all "0s" in the remainder of the payload.

FIG. 5 shows in block form the internal structure of the Type 2 disassembler **21***c*. In the ATM terminating LSI **21***b*, an ATM cell of AAL type 2 is temporarily stored in a FIFO (First-In First-Out) memory. The stored ATM cell of AAL type 2 is read from the FIFO memory, and transmitted to the Type 0 assembler **21***d* and an SF latch **32**. A shift register **31** is supplied with a timing signal of the start of the ATM cell, generates a latch timing signal with the first bit of a sixth byte, and sends the generated latch timing signal to the SF latch **32**. In response to the latch timing signal, the SF latch **32** latches 1 byte of data of the start field of the ATM cell. A flip-flop (FF) **33** holds the previous value of the SN (Sequence Number) of the first bit. A comparator (COMP) **34** compares the previous value of the SN with the present value of the SN, and sends an SN error to the Type 0 assembler **21***d* if the compared values agree with each other.

An EOR (Exclusive-OR) gate **35** exclusive-ORs the first through seventh bits of the start field, and sends a parity error to the Type 0 assembler **21***d* if the result of the exlusive-ORing of the first through seventh bits is "0".

A comparator (COMP) **38** compares the OSF (Offset Field) value indicated by the second through seventh bits of the start field with an output value from a CPS packet length counter **37**, and sends a length error to the Type 0 assembler **21***d* if the compared values do not agree with each other.

The CPS packet length counter **37** is initially set to the OSF value by a selector (SEL) **36**, and thereafter set to the LI value of each CPS packet transmitted from the Type 0 assembler **21***d*. In either case, the CPS packet length counter **37** counts down the packet length. When the count reaches "0", the CPS packet length counter **37** outputs an SOP (Start Of Packet) signal indicative of the timing of the start of each CPS packet to the Type 0 assembler **21***d*.

An OR gate **39** generates a read enable signal for the FIFO memory based on empty information of the FIFO memory from the ATM terminating LSI **21***b* and a signal indicative of a time to insert a header and pad of an ATM cell from the Type 0 assembler **21***d*, and sends the generated read enable signal to the FIFO memory. When the FIFO memory is empty or a header and pad of an ATM cell is inserted by the Type 0 assembler **21***d*, the OR gate **39** inhibits reading of data from the FIFO memory. An OSC (OSCillator) **40** sends a read clock signal to the FIFO memory.

FIG. 6 shows in block form the internal structure of the Type 0 assembler **21***d*.

As shown in FIG. 6, a modulo-**53** counter **41** is energized in response to an SOP signal from the Type 2 disassembler **21***c*, and transmits an output signal to a decoder **42**. Based on the output signal from the modulo-**53** counter **41**, the decoder **42** generates signals indicative of respective times to latch CID, LI, and HEC values of a CPS packet, and sends the generated signals respectively to a CID latch **45**, an LI latch **46**, and a HEC processor **43**. The decoder **42** also generates a write enable signal and sends the write enable signal to an FIFO memory **50**. The decoder **42** also sends a timing signal to a selector (SEL) **47**. Depending on the timing signal sent from the decoder **42**, the selector **47** selects one of the CID value sent from the CID latch **45**, the LI value sent from the LI latch **46**, and user traffic information sent from a shift register **44**, maps the selected value or information onto a 53-byte ATM cell, and stores the ATM cell in the FIFO memory **50**. Specifically, the CID value is recorded in eight low-order bits of a VCI field in the header of the ATM cell, and the LI value is recorded in an LIB field in the payload of the ATM cell.

The HEC processor **43** checks the header of the CPS packet for an error, and, sends an HEC error to an OR gate **48** if it detects an error. When the OR gate **48** is supplied with either one of an HEC error, an SN error, a parity error, and a length error, the OR gate **48** sends a reset signal to the FIFO memory **50**, the HEC processor **43**, the CID latch **45**, the LI latch **46**, and the modulo-**53** counter **41** for thereby resetting them. An OSC **49** sends a write clock signal to the FIFO memory **50**.

FIG. 7 shows in block form a downward processing section of each of the BTS interfaces **21**, **22** of the base-station host system **13**. Since the BTS interfaces **21**, **22** are structurally identical to each other, the structure of the downward processing section of the BTS interface **21** will be described below.

The downward processing section of the BTS interface **21** comprises SONET (Synchronous Optical Network) terminating LSI **21***e*, a Type 0 disassembler **21***f*, a Type 2 assembler **21***g*, and a T1 terminating LSI **21***h*. The SONET terminating LSI **21***e* is supplied with an ATM cell of AAL Type 0 from the ATM SW unit **23**. The SONET terminating LSI **21***e* terminates a SONET, extracts a clock signal, extracts an alarm signal, and extracts an ATM cell. The Type 0 disassembler **21***f* generates a CPS packet based on the ATM cell of AAL Type 0. The Type 2 assembler **21***g* collects a plurality of CPS packets, and generates an ATM cell of AAL type 2. The terminating LSI **21***h* maps the generated ATM cell of AAL type 2 onto a T1 frame, and transmits the ATM cell of AAL type 2 to the base transceiver stations **11**, **12**. The terminating LSI **21***h* also maps an ATM cell of AAL Type 5 sent from the monitor/controller **27** onto a T1 frame, and transmits the ATM cell of AAL type 5 to the base transceiver stations **11**, **12**.

FIG. 8 shows in block form the internal structure of the Type 0 disassembler **21***f*.

As shown in FIG. 8, in the SONET terminating LSI **21***e*, an ATM cell of AAL type 0 is temporarily stored in a FIFO memory. The stored ATM cell of AAL type 0 is read from the FIFO memory. A modulo-**53** counter **52** is energized in timed relation to the start of the ATM cell. Based on an output signal from the modulo-**53** counter **52**, a decoder **55** generates various timing signals and sends the generated timing signals to various circuits. A selector (SEL) **59** maps UUI information and PT information supplied from an internal register **56**, eight low-order bits of a VCI transmitted from a flip-flop (FF) **57**, and an LIB from a flip-flop (FF) **58** onto the respective fields UUI, PT, CID, LI of the header of a CPS packet. An HEC **60** generates and supplies a HEC value to a selector (SEL) **63**, which maps the HEC value onto a HEC field of the header of a CPS packet. The selector

63 generates a CPS packet from the header, thus produced, and user traffic information from a shift register 51, and transmits the generated CPS packet to the Type 2 assembler 21g.

A counter 65 generates "remaining packet length" information of six bits based on the LI, and sends the generated "remaining packet length" information to the Type 2 assembler 21g. An AND gate 64 sends a write disable signal to the Type 2 assembler 21g while a pad is being inserted.

FIG. 9 shows in block form the internal structure of the Type 2 assembler 21g.

As shown in FIG. 9, a modulo-53 counter 74 is energized in response to a write stop signal from the Type 2 disassembler 21c. Based on an output signal from the modulo-53 counter 74, a decoder 75 generates various timing signals and sends the generated timing signals to various circuits. A flip-flop (FF) 72 generates an SN value of one bit. A flip-flop (FF) 73 generates an OSF (Offset Field) value of 6 bits based on the "remaining packet length" information. An EOR gate 76 generates a parity value of one bit. These generated values are mapped thereby to generate a start field of eight bits. A selector (SEL) 77 maps an ATM cell header information from an internal register 71, a CPS packet from the Type 0 disassembler 21f, and the generated start field, generating an ATM cell of AAL Type 2, and sends the generated ATM cell of AAL Type 2 to an FIFO memory 78. The FIFO memory 78 stores the ATM cell according to a write permit enable signal from an AND gate 79.

According to the first embodiment, as shown in FIG. 2, each of the base transceiver stations 11, 12 has CDMA signal processors for effecting CDMA radio communications with mobile stations. Since signaling information is transmitted within user traffic information according to the CDMA process, the base-station host system 13 is required to separate the signaling information from the user traffic information somewhere therein. For reverse communications, the base-station host system 13 is required to insert signaling information into user traffic information somewhere therein.

According to the first embodiment, signaling information is separated and inserted by the voice signal processors 24, 25. Separation and insertion of signaling information with the voice signal processors 24, 25 is most efficient in view of the fact that the voice signal processors 24, 25 code and decode signaling user traffic information according to the QCELP process, the voice signal processors 24, 25 need to select one of items of user traffic information that are supplied from a plurality of base transceiver stations due to a soft hand-off process of the CDMA process, and one of items of signaling information also needs to be selected somewhere in the base-station host system 13.

Specifically, separation and insertion of signaling information with the voice signal processors 24, 25 requires a less amount of hardware than with other circuits in the base-station host system 13, and greatly reduces a burden on the monitor/controller 27 because the signaling information is supplied altogether to the monitor/controller 27. Because user traffic information and signaling information stay together until they reach the voice signal processors 24, 25, the amount of traffic in the base-station host system 13 may be relatively small.

Although the first embodiment is applied to CDMA radio communications, the principles of the present invention are not limited to CDMA radio communications, but are also applicable to other types of radio communications.

According to the first embodiment, order wire service information is transmitted by way of ATM cells over entrance links between the base transceiver stations 11, 12 and the base-station host system 13. Consequently, no dedicated lines are required, and hence no expenditure of expenses for such dedicated lines is needed. Use of ATM cells of AAL Type 2 over the entrance links makes it possible to efficiently transmit order wire service information without permanently occupying the entrance links and restricting the traffic. In the base-station host system 13, ATM cells of AAL Type 0 converted from ATM cells of AAL Type 2 are transmitted. Therefore, order wire service information can be routed with an ATM switch which can operate at a high speed and is not subject to a heavy processing burden. Since order wire service information can be processed by a processor for user traffic information and signaling information, the hardware requirement can be simplified.

According to the first embodiment, furthermore, BTS monitoring control information is transmitted using ATM cells of AAL type 5. Inasmuch as the BTS monitoring control information is generally a large amount of information that cannot be divided and is generated at all times, it does not lend itself to being transmitted using ATM cells of AAL type 2. For these reasons, the BTS monitoring control information is transmitted using ATM cells of AAL type 5.

A base-station host system according to a second embodiment of the present invention will be described below.

The base-station host system according to the second embodiment is basically of the same structure as the base-station host system according to the first embodiment. Therefore, details of the base-station host system according to the second embodiment which are identical to those of the base-station host system according to the first embodiment will not be described, and only different details of the base-station host system according to the second embodiment will be described below.

FIGS. 10(A), 10(B), and 10(C) show the mutual relationship of an ATM cell of AAL Type 2, a CPS packet, and an ATM cell of AAL Type 0 in the base-station host system according to the second embodiment.

FIG. 10(A) shows the structure of an ATM cell of AAL Type 2. The ATM cell of AAL Type 2 shown in FIG. 10(A) is identical to the ATM cell of AAL Type 2 shown in FIG. 4(A). FIG. 10(B) shows the structure of a CPS packet. As shown in FIG. 10(B), the CPS packet comprises a header of three bytes and a variable-length payload. The header is identical to the header of a CPS packet in the first embodiment shown in FIG. 4(A). The payload comprises user traffic information, rate information (RI) 81 mapped thereonto at the start of the payload and CRC (Cyclic Redundancy Check) information 82 mapped thereonto at the end of the payload. FIG. 10(C) shows the structure of an ATM cell of AAL Type 0. As shown in FIG. 10(C), the ATM cell of AAL Type 0 comprises a header of five bytes and a payload of 48 bytes. The header is identical to the header of an ATM cell in the first embodiment shown in FIG. 4(C). The payload has rate information 81 mapped thereonto at the start of the payload, user traffic information mapped thereonto after the rate information 81, and a pad of all "0s" in the remainder of the payload.

The rate information 81 is information indicative of a data rate (transmission rate or compression percentage). According to the CDMA process, a vocoder is employed on the QCELP process, and the vocoder codes and decodes data according to a data rate. Therefore, since the rate information 81 is transmitted, user traffic information can be read easily when it is to be decoded. When an ATM cell of AAL

Type 0 is converted into an ATM cell of AAL Type 2, an effective data length except the pad in the ATM cell of AAL Type 0 can easily be determined.

The CRC information **82** represents an error detecting code for detecting an error in the rate information **81** and user traffic information in the payload of a CPS packet. With the CRC information **82** mapped onto the CPS packet, it is possible to check and correct errors in the user traffic information and rate information **81** in the payload of the CPS packet.

The mapping of the CRC information **82** is highly effective because signaling information that is not allowed to have even an error of single bit is combined with user traffic information according to the CDMA process.

In the second embodiment, the rate information **81** and the CRC information **82** are mapped onto the payload of the CPS packet. However, one of the rate information **81** and the CRC information **82** may be mapped onto the payload of the CPS packet.

According to the present invention, as described above, when the base-station host system receives a cell containing a plurality of packets (an ATM cell of AAL Type 2), the base-station host system separates the packets contained by the cell, converts them into an internally processable cell (an ATM cell of AAL Type 0), and routes the internally processable cell with the ATM switch. Therefore, the cell can be routed at a high speed with a reduced burden on the routing process.

The base-station host system effects a conversion between a CID field value of a CPS packet and a VPI/VCI in an ATM cell of AAL Type 0. Consequently, routing for each user can be effected with only the ATM layer without involving an ATM adaptation layer.

The base-station host system also effects a conversion between an LI field value of a CPS packet and effective data information (LIB value) in an ATM cell of AAL Type 0. Consequently, effective data in a payload can easily be read by a circuit which has read an ATM cell of AAL Type 0.

In the CDMA process, rate information of user traffic information is mapped onto the payload of a CPS packet. This allows the voice signal processors of the base-station host system to extract user traffic information with ease.

CRC information is also mapped onto the payload of a CPS packet, so that user traffic information can be transferred accurately.

In the CDMA process, signaling information is separated from user traffic information and signaling information is inserted into user traffic information by the voice signal processors of the base-station host system. In this manner, the base-station host system is subject to a reduced burden for a signaling process in a soft hand-off process.

Order wire service information is transmitted using ATM cells over the entrance links. Therefore, dedicated lines are not required, and the cost of the base-station host system is reduced.

Furthermore, order wire service information is transmitted using ATM cells of AAL Type 2. Therefore, a processor which processes user traffic information that is also transmitted using ATM cells of AAL Type 2 can be used to process order wire service information. As a consequence, the cost of the base-station host system is reduced, and the processing of order wire service information is simplified.

In addition, BTS monitoring control information is transmitted by way of ATM cells. No dedicated line for controlling the base-station host system is required, and the cost of the base-station host system is reduced.

The foregoing is considered as illustrative only of the principles of the present invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and applications shown and described, and accordingly, all suitable modifications and equivalents may be regarded as falling within the scope of the invention in the appended claims and their equivalents.

What is claimed is:

1. A host system for controlling a base station to transmit a signal to and receive a signal from the base station by way of a cell containing a plurality of packets representing signals from the base station to a plurality of base stations or from a plurality of base stations to the base station, comprising:

packet extracting means for extracting a plurality of individual packets contained in a cell;

cell generating means for generating an internally processable cell based on the individual packets extracted by said packet extracting means;

switching means for switching internally processable cells generated by said cell generating means depending on routes thereof;

packet generating means for generating packets based on an internally processable cell destined for a base station; and

cell transmitting means for generating a cell containing a plurality of packets destined to the same base station from the packets which are generated by said packet generating means and transmitting the generated cell to the base station,

wherein each of the individual packets extracted by said packet extracting means includes a payload carrying at least user traffic information, and the internally processable cell based on which the packets are generated by said packet generating means includes a payload carrying at least user traffic information and a cell containing a plurality of packets transmitted from the base station represents a signal processed according to a CDMA process, and the payload of each of the packets contained in the cell includes rate information indicative of a data rate of the user traffic information, and wherein said cell generating means comprises means for generating the internally processable cell based on information including the rate information.

2. A host system according to claim **1**, wherein said cell generating means comprises:

VPI/VCI value generating means for generating a VPI/VCI value of each of the internally processable cells based on a CID field value in the header of each of the packets extracted by said packet extracting means; and wherein said packet generating means comprises:

CID field value generating means for generating a CID field value for a packet based on a VPI/VCI value in the header of the internally processable cell destined for the base station.

3. A host system according to claim **1**, wherein said cell generating means comprises:

effective data length adding means for extracting an LI field in the header of each of the packets extracted by said packet extracting means, and adding the extracted LI field as effective data length information to the payload of each of the internally processable cells; and wherein said packet generating means comprises:

LI field value adding means for extracting effective data length information in the payload of the internally

processable cell destined for the base station, and adding the extracted effective data length information to an LI field in the header of a packet.

4. A host system according to claim 1, wherein the payload of a CPS packet contained in the cell includes a CRC information.

5. A host system according to claim 1, wherein a cell containing a plurality of packets transmitted from the base station represents a signal processed according to a CDMA process, further comprising:

separating means for receiving the internally processable cell generated by said cell generating means via said switching means, and separating user traffic information and signaling information from information carried by the payload of the received internally processable cell; and

transmitting means for inserting the signaling information into the user traffic information, adding the signaling information and the user traffic information to the payload of an internally processable cell, and transmitting the internally processable cell via said switching means to said packet generating means.

6. A host system according to claim 1, wherein order wire service information is carried by the payload of each of the packets extracted by said packet extracting means, and order wire service information is carried by the payload of the internally processable cell based on which the packets are generated by said packet generating means.

* * * * *

US006512747B1

(12) United States Patent
Umeuchi et al.

(10) Patent No.: US 6,512,747 B1
(45) Date of Patent: Jan. 28, 2003

(54) ATM TRANSMISSION SYSTEM

(75) Inventors: **Makoto Umeuchi**, Tokyo (JP); **Masamitsu Nakura**, Tokyo (JP); **Masahiro Umehira**, Tokyo (JP)

(73) Assignee: **Nippon Telegraph and Telephone Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/262,111**

(22) Filed: **Mar. 4, 1999**

(30) **Foreign Application Priority Data**

Mar. 5, 1998 (JP) 10-053808

(51) **Int. Cl.**[7] **H04B 7/00**; H04L 12/28; H04L 12/56

(52) **U.S. Cl.** **370/310.1**; 370/395.6

(58) **Field of Search** 370/310.1, 347, 370/395.1, 395.6, 395.65, 389, 394, 412; 714/748

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,572,522 A	* 11/1996	Calamvokis et al.	....	370/390
5,764,641 A	* 6/1998	Lin	....	370/412
6,151,299 A	* 11/2000	Lyon et al.	....	370/229
6,373,842 B1	* 4/2002	Coverdale et al.	....	370/394

FOREIGN PATENT DOCUMENTS

JP	8-163141	6/1996
JP	10-135959	5/1998

OTHER PUBLICATIONS

WO 97/50276, Dec. 31, 1997.

* cited by examiner

Primary Examiner—Kwang Bin Yao
Assistant Examiner—Kevin C. Harper
(74) *Attorney, Agent, or Firm*—Arent Fox Kintner Plotkin & Kahn, PLLC

(57) **ABSTRACT**

In an ATM transmission system in which a plurality of ATM cells are grouped to a packet with an end of ATM cell having an EOP (End Of Packet) flag, a transmitting station comprises a transmit buffer for storing temporarily ATM cells to be transmitted, a transmit cell process means which discards all the ATM cells in the group in case that a NAK response indicating loss or wrong reception of an ATM cell is received from a receiving station, and an EOP cell generator for transmitting an EOP cell which has said EOP flag in stead of the discarded ATM cells. As no ATM cell in a packet is transmitted after an erroneous ATM cell is detected, no useless ATM cell which would be discarded in a destination terminal equipment because of an erroneous ATM cell occupies a transmission line when an erroneous ATM cell is detected, and traffic is saved.

5 Claims, 15 Drawing Sheets

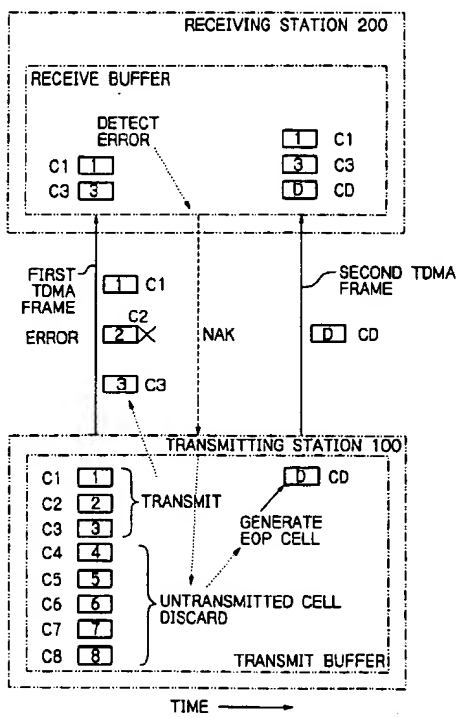


Fig. 1

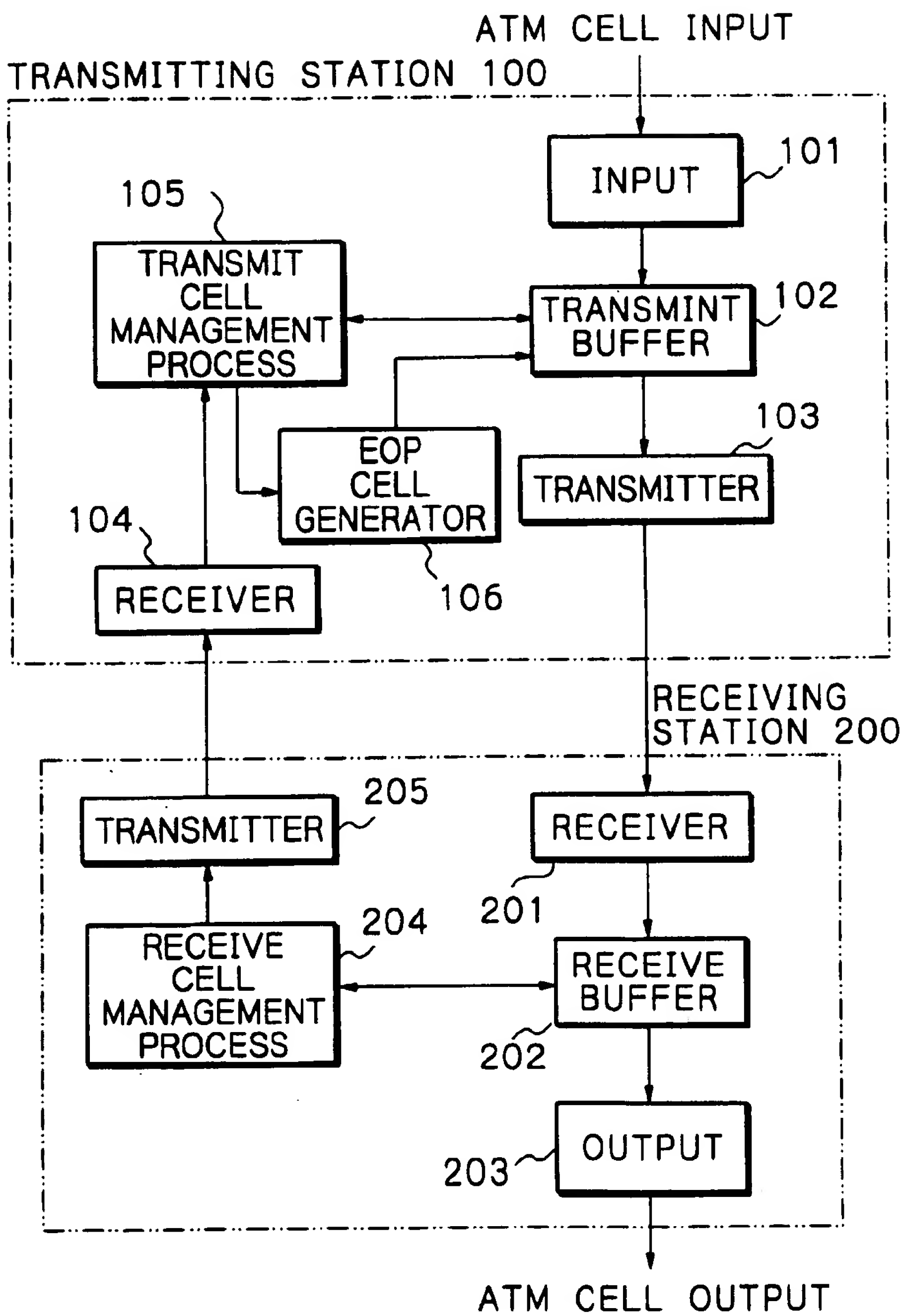

ATM CELL INPUT
TRANSMITTING STATION 100
INPUT
101
105
TRANSMIT CELL MANAGEMENT PROCESS
TRANSMINT BUFFER
102
103
EOP CELL GENERATOR
TRANSMITTER
104
RECEIVER
106
RECEIVING STATION 200
205
TRANSMITTER
RECEIVER
201
204
RECEIVE CELL MANAGEMENT PROCESS
RECEIVE BUFFER
202
203
OUTPUT
ATM CELL OUTPUT

Fig. 2

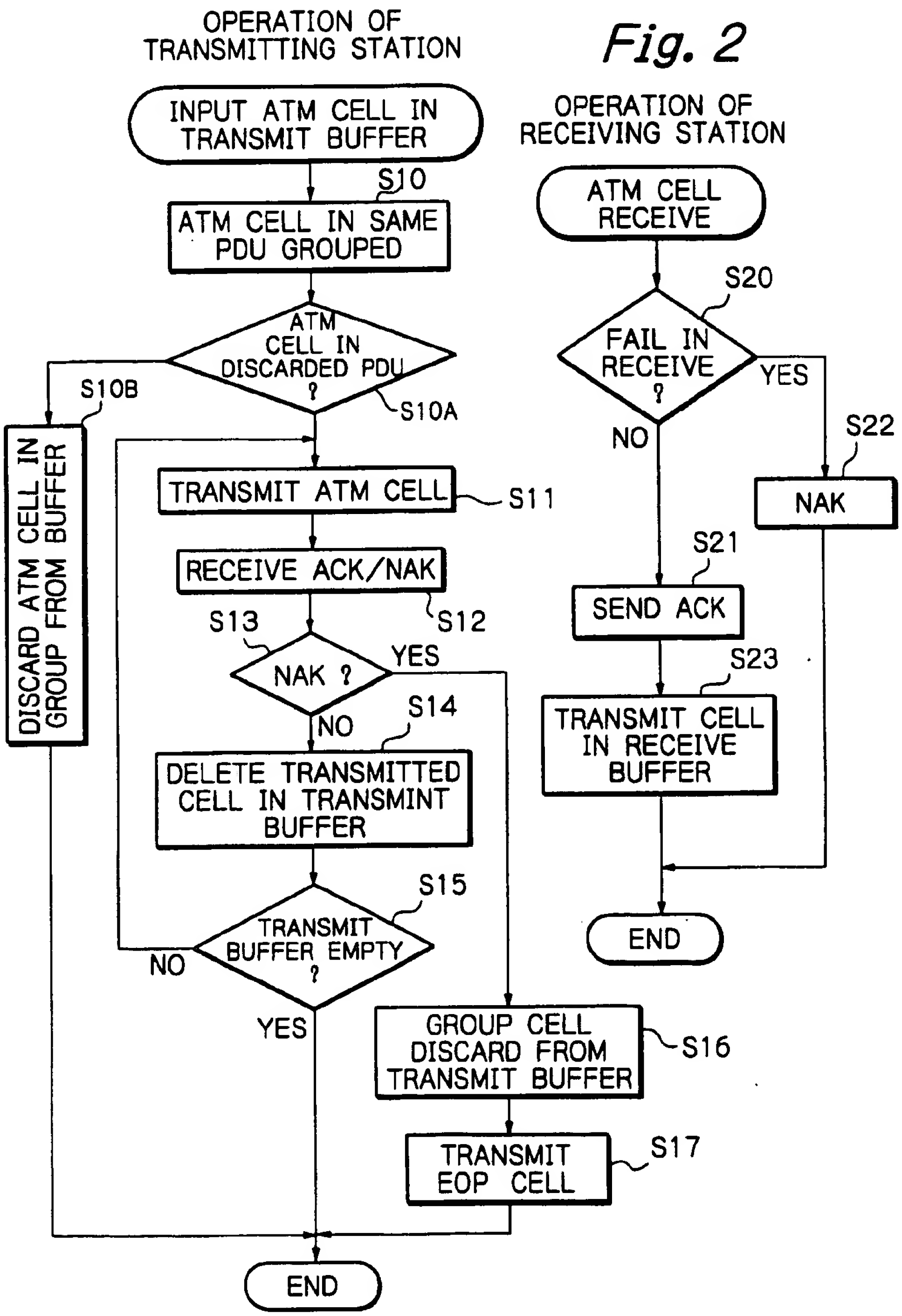

OPERATION OF TRANSMITTING STATION
INPUT ATM CELL IN TRANSMIT BUFFER
S10
ATM CELL IN SAME PDU GROUPED
ATM CELL IN DISCARDED PDU ?
S10A
S10B
DISCARD ATM CELL IN GROUP FROM BUFFER
TRANSMIT ATM CELL
S11
RECEIVE ACK/NAK
S12
S13
NAK ?
YES
NO
S14
DELETE TRANSMITTED CELL IN TRANSMINT BUFFER
S15
TRANSMIT BUFFER EMPTY ?
NO
YES
GROUP CELL DISCARD FROM TRANSMIT BUFFER
S16
TRANSMIT EOP CELL
S17
END
OPERATION OF RECEIVING STATION
ATM CELL RECEIVE
S20
FAIL IN RECEIVE ?
YES
NO
S22
NAK
S21
SEND ACK
S23
TRANSMIT CELL IN RECEIVE BUFFER
END

Fig. 3

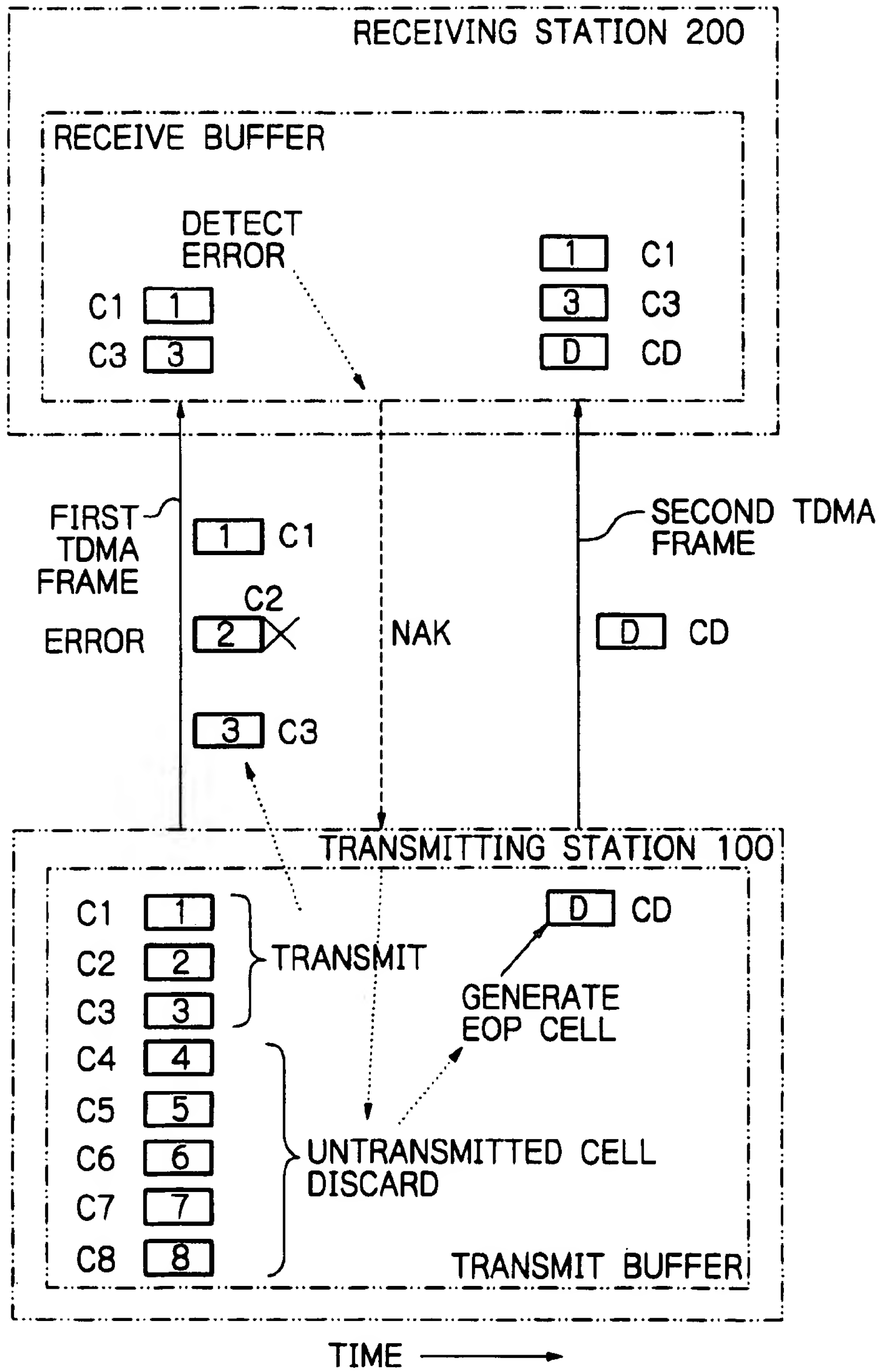

RECEIVING STATION 200
RECEIVE BUFFER
DETECT ERROR
C1 1
C3 3
1 C1
3 C3
D CD
FIRST TDMA FRAME
1 C1
C2
ERROR
2
3 C3
NAK
SECOND TDMA FRAME
D CD
TRANSMITTING STATION 100
C1 1
C2 2
C3 3
TRANSMIT
C4 4
C5 5
C6 6
C7 7
C8 8
UNTRANSMITTED CELL DISCARD
GENERATE EOP CELL
D CD
TRANSMIT BUFFER
TIME

Fig. 4

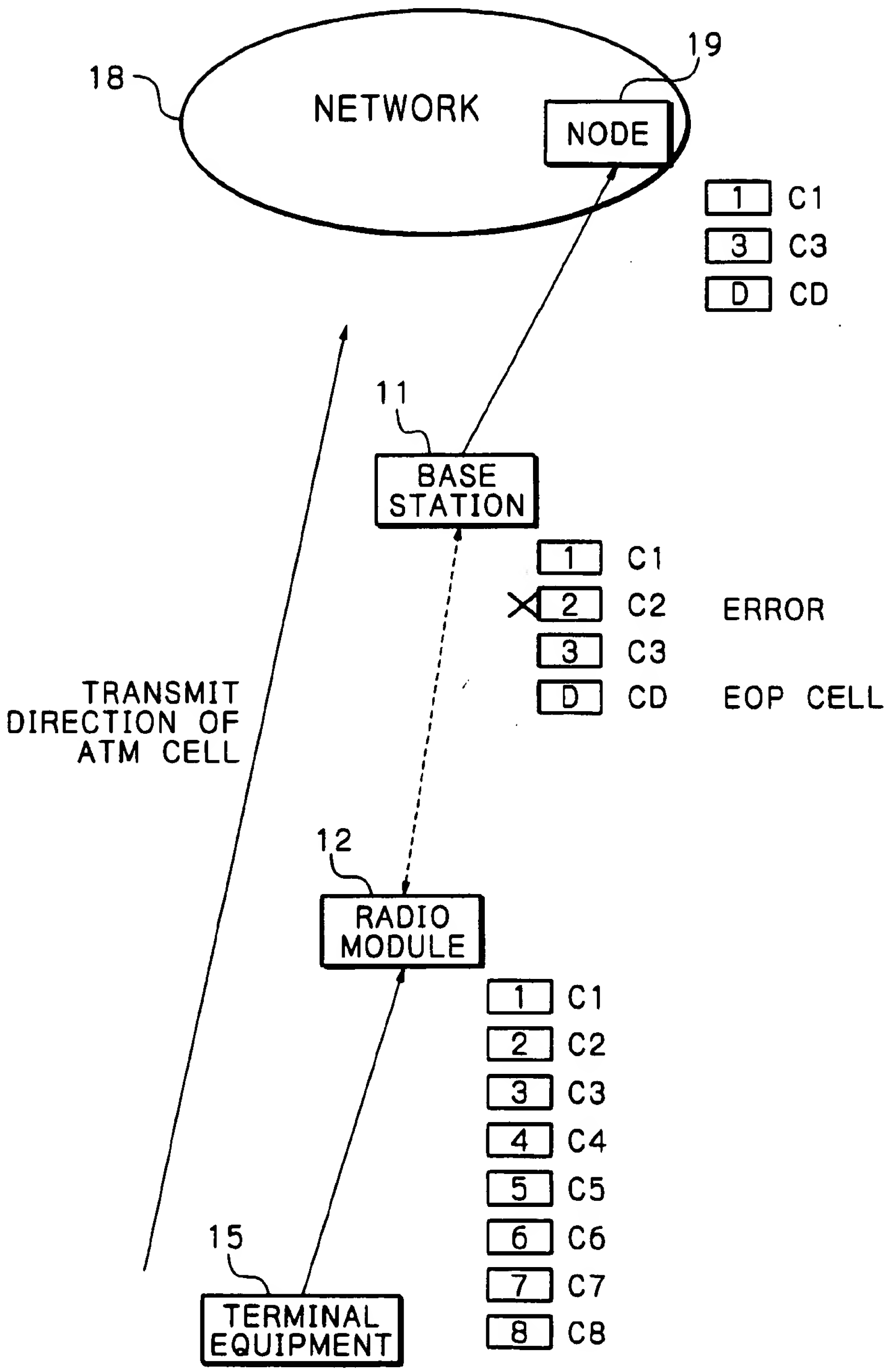
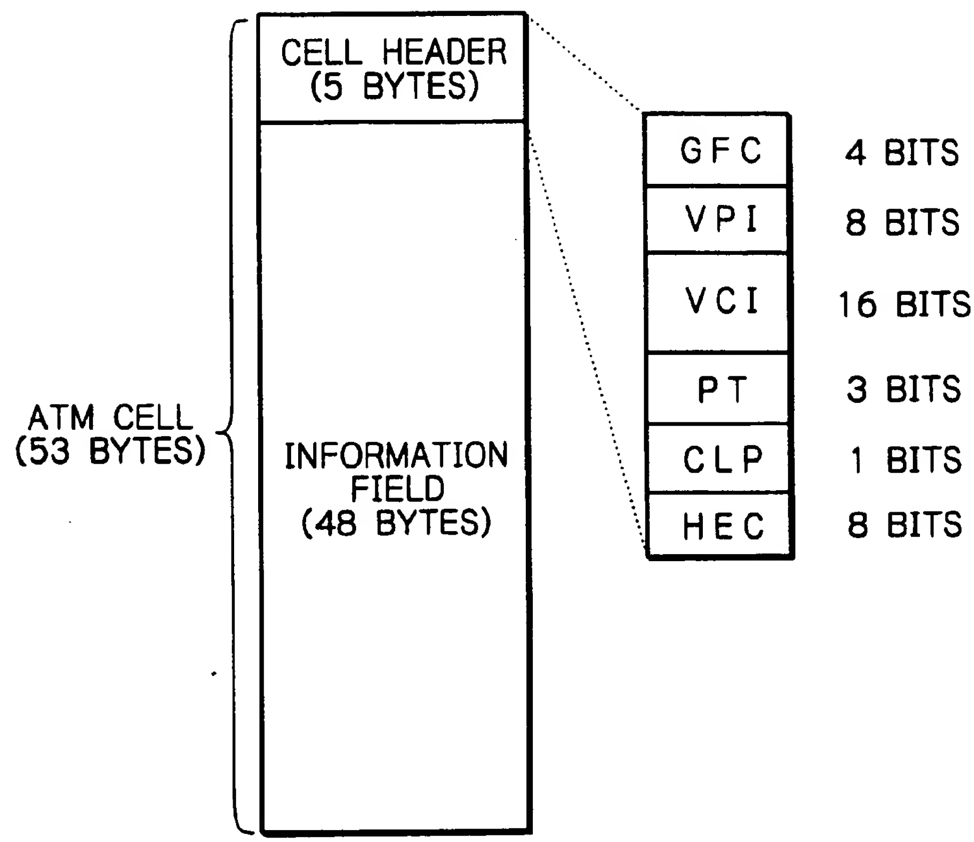

18
NETWORK
19
NODE
1 C1
3 C3
D CD
11
BASE STATION
1 C1
2 C2 ERROR
3 C3
D CD EOP CELL
TRANSMIT DIRECTION OF ATM CELL
12
RADIO MODULE
1 C1
2 C2
3 C3
4 C4
5 C5
6 C6
7 C7
8 C8
15
TERMINAL EQUIPMENT

Fig. 5



GFC : GENERIC FLOW CONTROL

VPI : VIRTUAL PATH IDENTIFIER

VCI : VIRTUAL CHANNEL IDENTIFIER

PT : PAYLOAD TYPE

CLP : CELL LOSS PRIORITY

HEC : HEADER ERROR CONTROL

Fig. 6

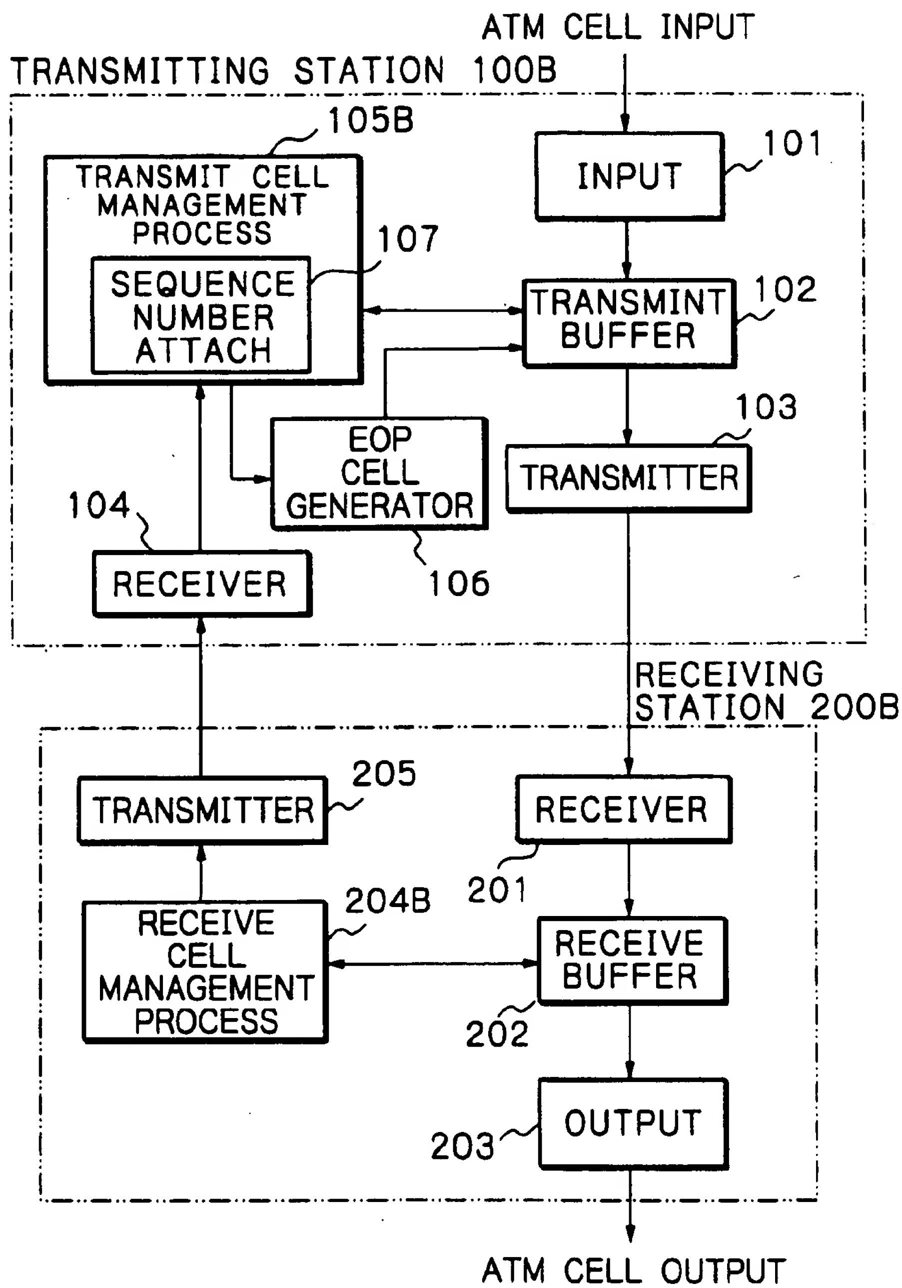
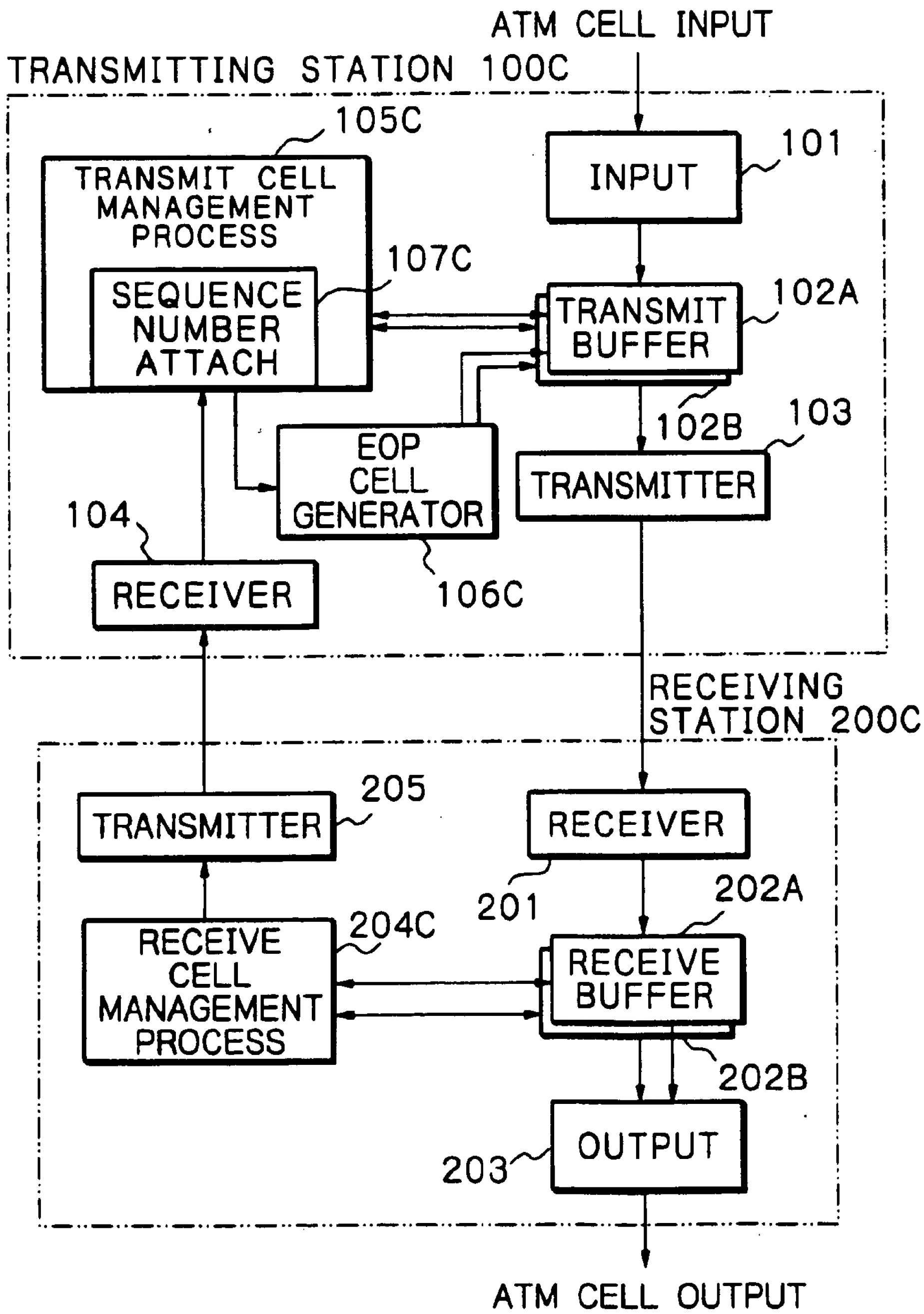

ATM CELL INPUT
TRANSMITTING STATION 100B
105B
TRANSMIT CELL MANAGEMENT PROCESS
SEQUENCE NUMBER ATTACH
107
INPUT
101
TRANSMINT BUFFER
102
103
TRANSMITTER
EOP CELL GENERATOR
104
RECEIVER
106
RECEIVING STATION 200B
TRANSMITTER
205
RECEIVER
201
204B
RECEIVE CELL MANAGEMENT PROCESS
RECEIVE BUFFER
202
203
OUTPUT
ATM CELL OUTPUT

Fig. 7



ATM CELL INPUT
TRANSMITTING STATION 100C
105C
TRANSMIT CELL MANAGEMENT PROCESS
SEQUENCE NUMBER ATTACH
107C
INPUT
101
TRANSMIT BUFFER
102A
102B
103
EOP CELL GENERATOR
TRANSMITTER
104
RECEIVER
106C
RECEIVING STATION 200C
TRANSMITTER
205
RECEIVER
201
202A
204C
RECEIVE CELL MANAGEMENT PROCESS
RECEIVE BUFFER
202B
OUTPUT
203
ATM CELL OUTPUT

Fig. 8

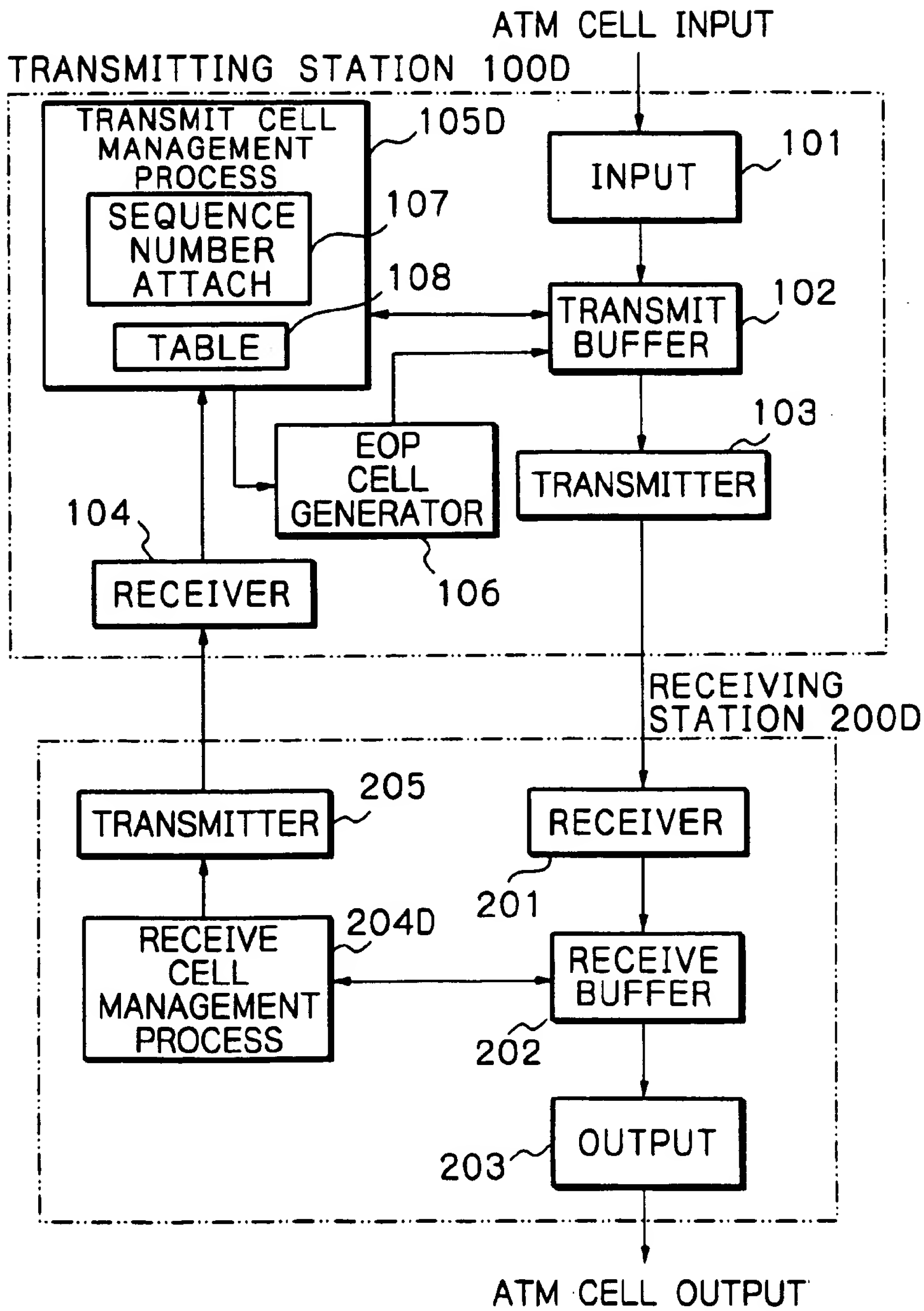

ATM CELL INPUT
TRANSMITTING STATION 100D
TRANSMIT CELL MANAGEMENT PROCESS
105D
SEQUENCE NUMBER ATTACH
107
TABLE
108
INPUT
101
TRANSMIT BUFFER
102
103
TRANSMITTER
EOP CELL GENERATOR
106
104
RECEIVER
RECEIVING STATION 200D
TRANSMITTER
205
RECEIVER
201
RECEIVE CELL MANAGEMENT PROCESS
204D
RECEIVE BUFFER
202
OUTPUT
203
ATM CELL OUTPUT

Fig. 9

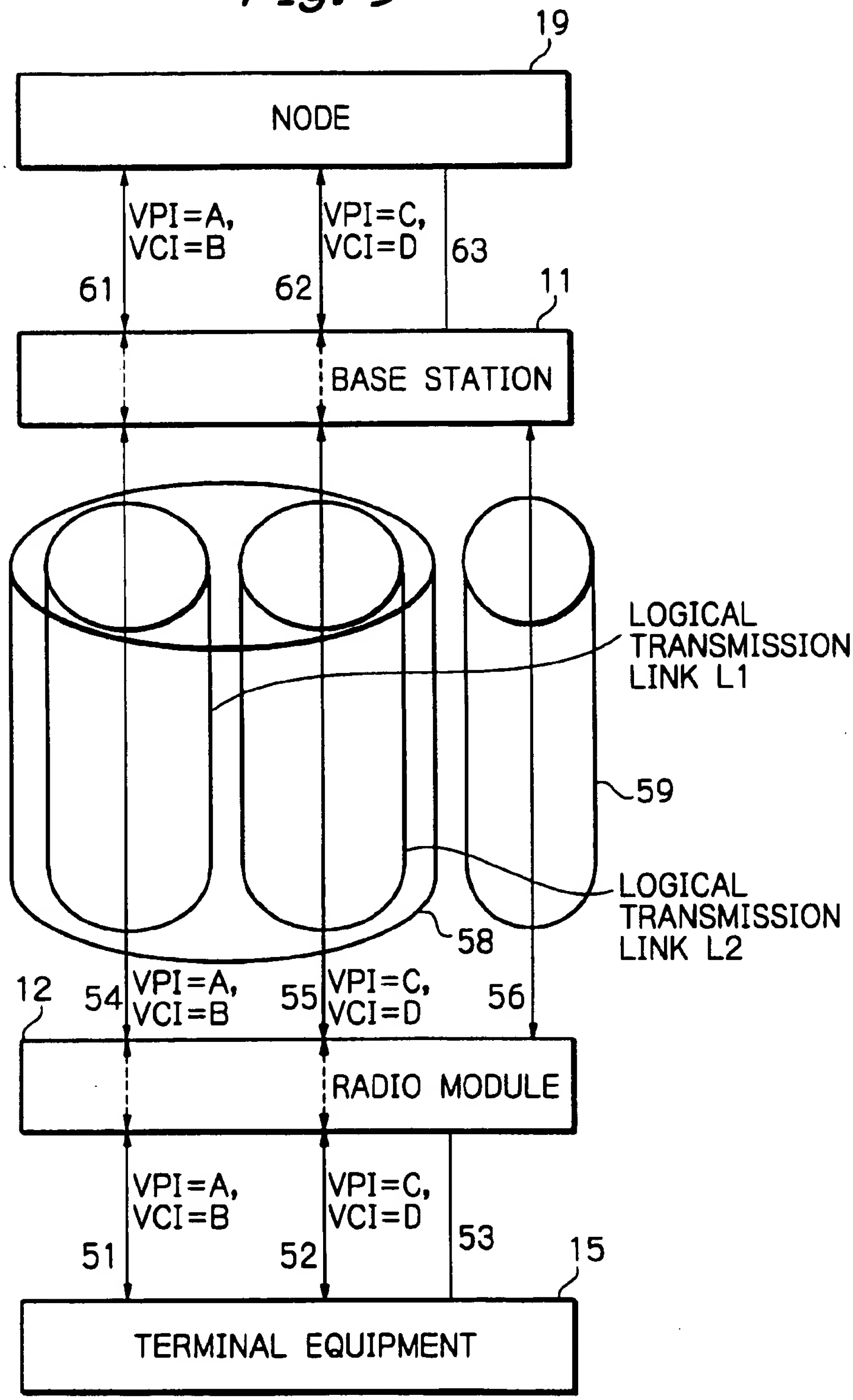

19
NODE
VPI=A,
VCI=B
61
VPI=C,
VCI=D
62
63
11
BASE STATION
LOGICAL
TRANSMISSION
LINK L1
59
LOGICAL
TRANSMISSION
LINK L2
58
12
54
VPI=A,
VCI=B
55
VPI=C,
VCI=D
56
RADIO MODULE
VPI=A,
VCI=B
51
VPI=C,
VCI=D
52
53
15
TERMINAL EQUIPMENT

Fig. 10

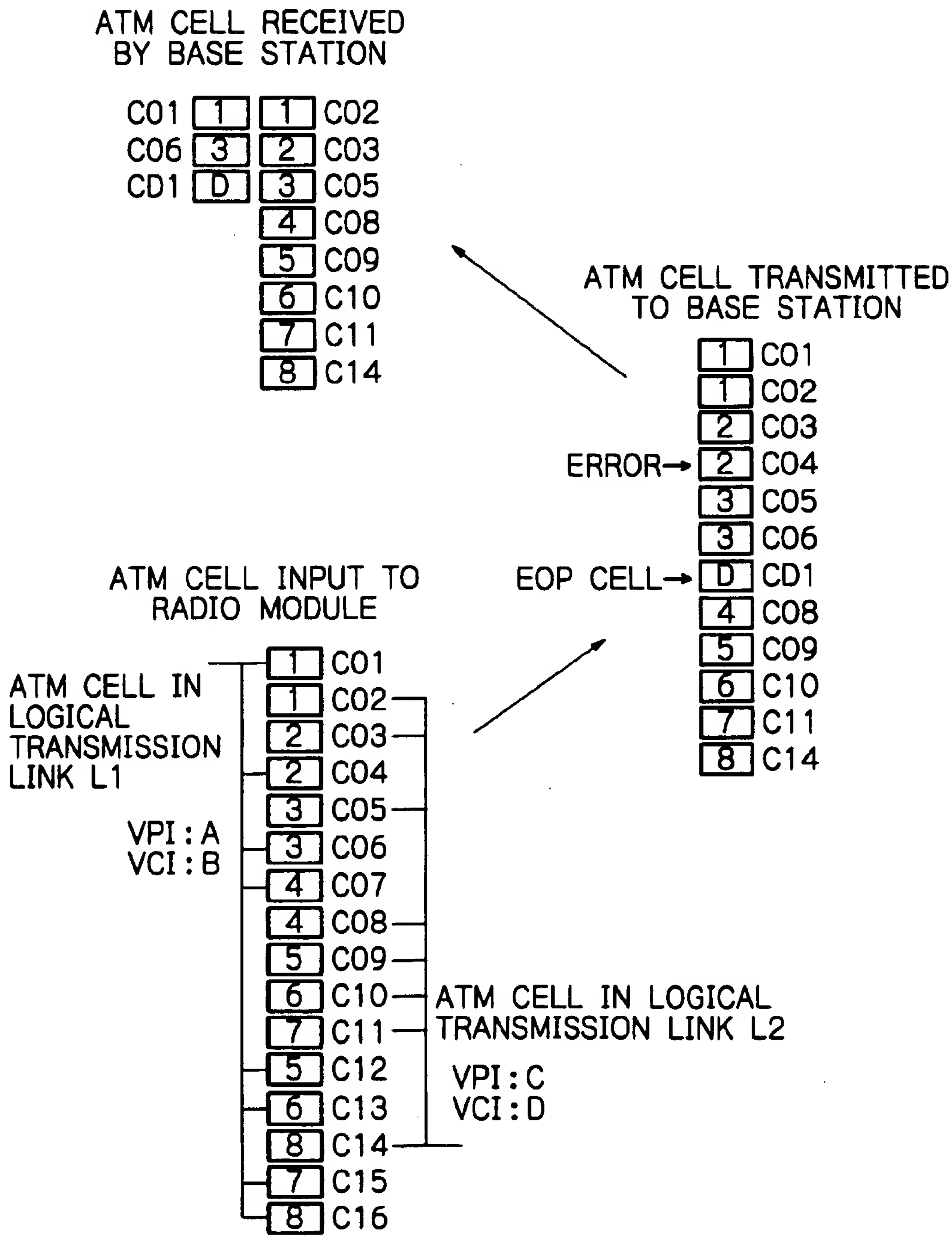

ATM CELL RECEIVED BY BASE STATION
C01 1
C06 3
CD1 D
1 C02
2 C03
3 C05
4 C08
5 C09
6 C10
7 C11
8 C14
ATM CELL TRANSMITTED TO BASE STATION
1 C01
1 C02
2 C03
ERROR→ 2 C04
3 C05
3 C06
EOP CELL→ D CD1
4 C08
5 C09
6 C10
7 C11
8 C14
ATM CELL INPUT TO RADIO MODULE
ATM CELL IN LOGICAL TRANSMISSION LINK L1
VPI : A
VCI : B
1 C01
1 C02
2 C03
2 C04
3 C05
3 C06
4 C07
4 C08
5 C09
6 C10
7 C11
5 C12
6 C13
8 C14
7 C15
8 C16
ATM CELL IN LOGICAL TRANSMISSION LINK L2
VPI : C
VCI : D

Fig. 11 PRIOR ART

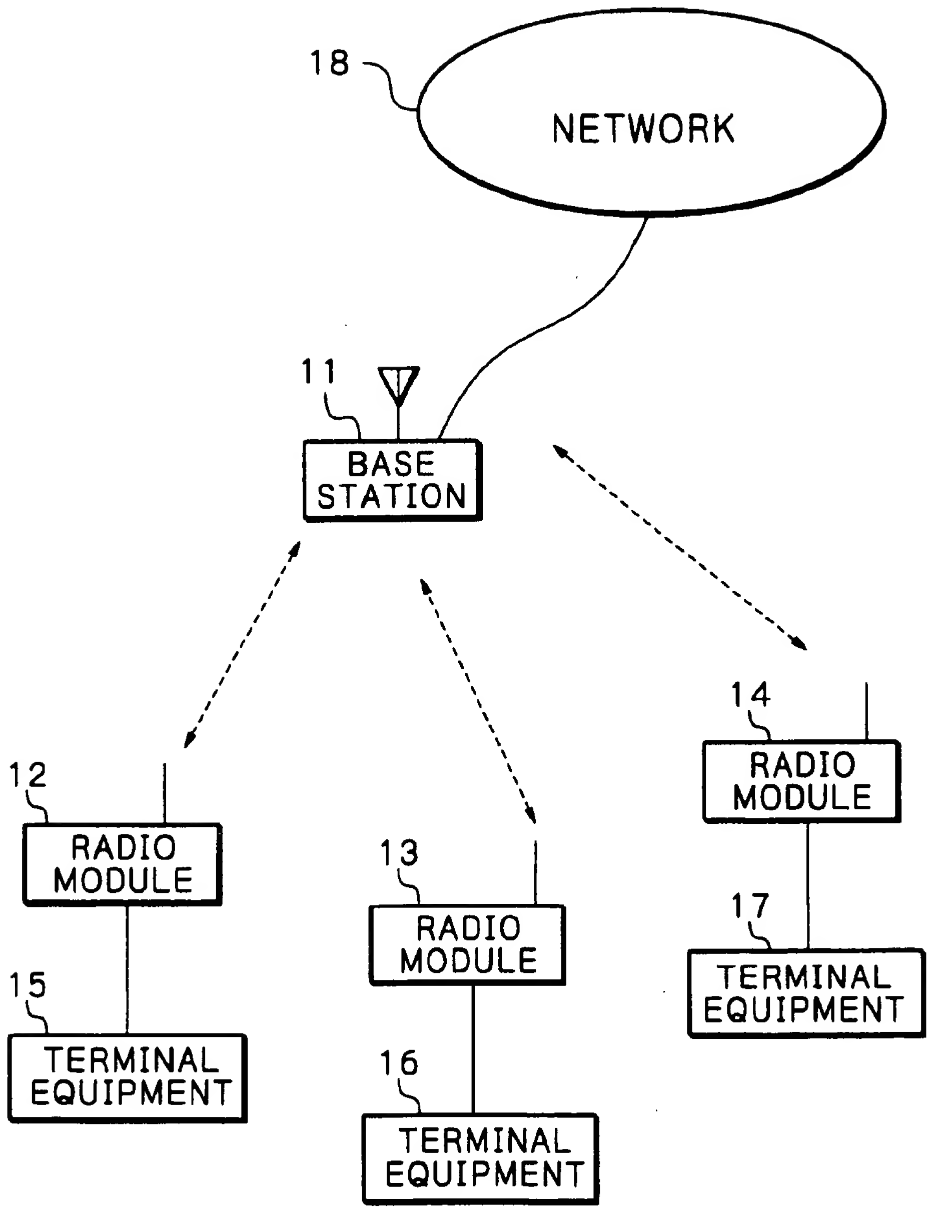


Fig. 12 PRIOR ART

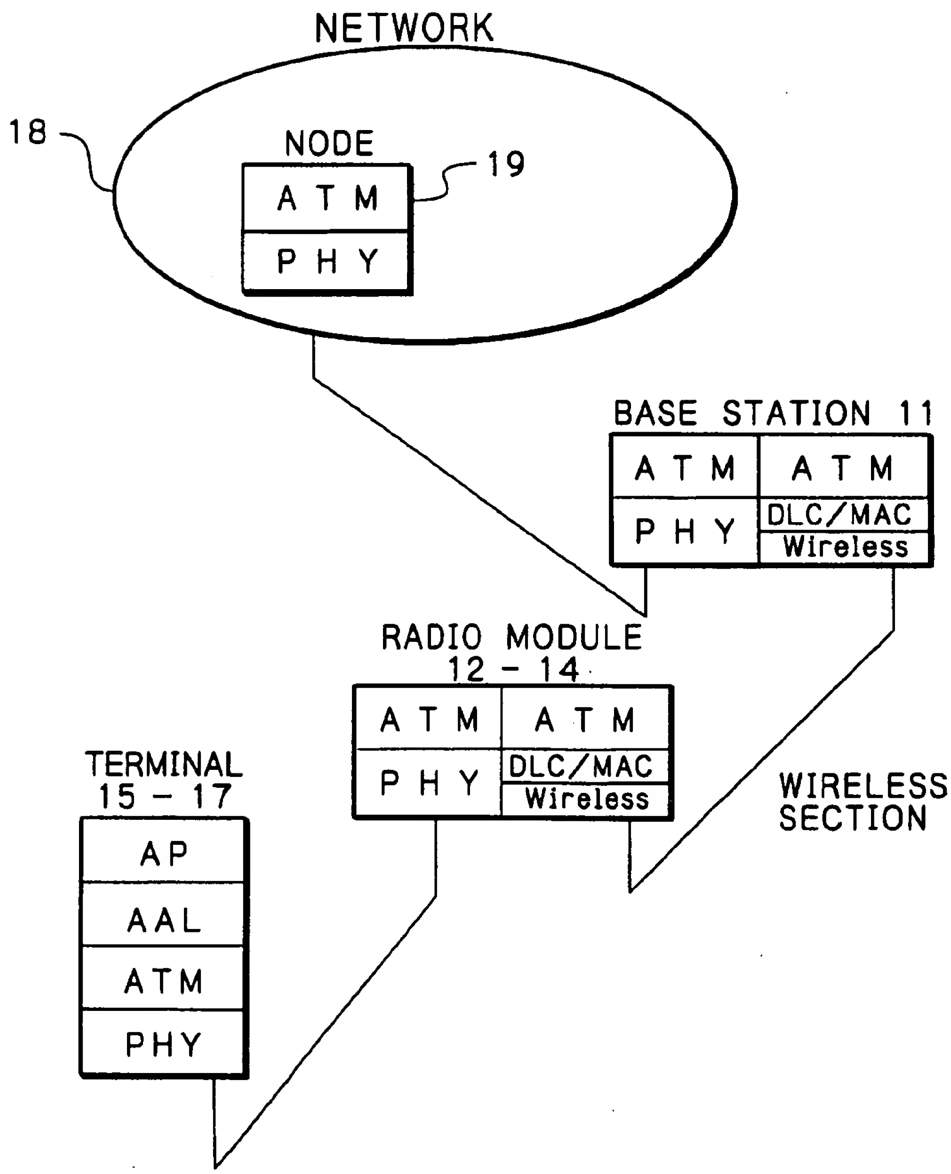


Fig. 13 PRIOR ART

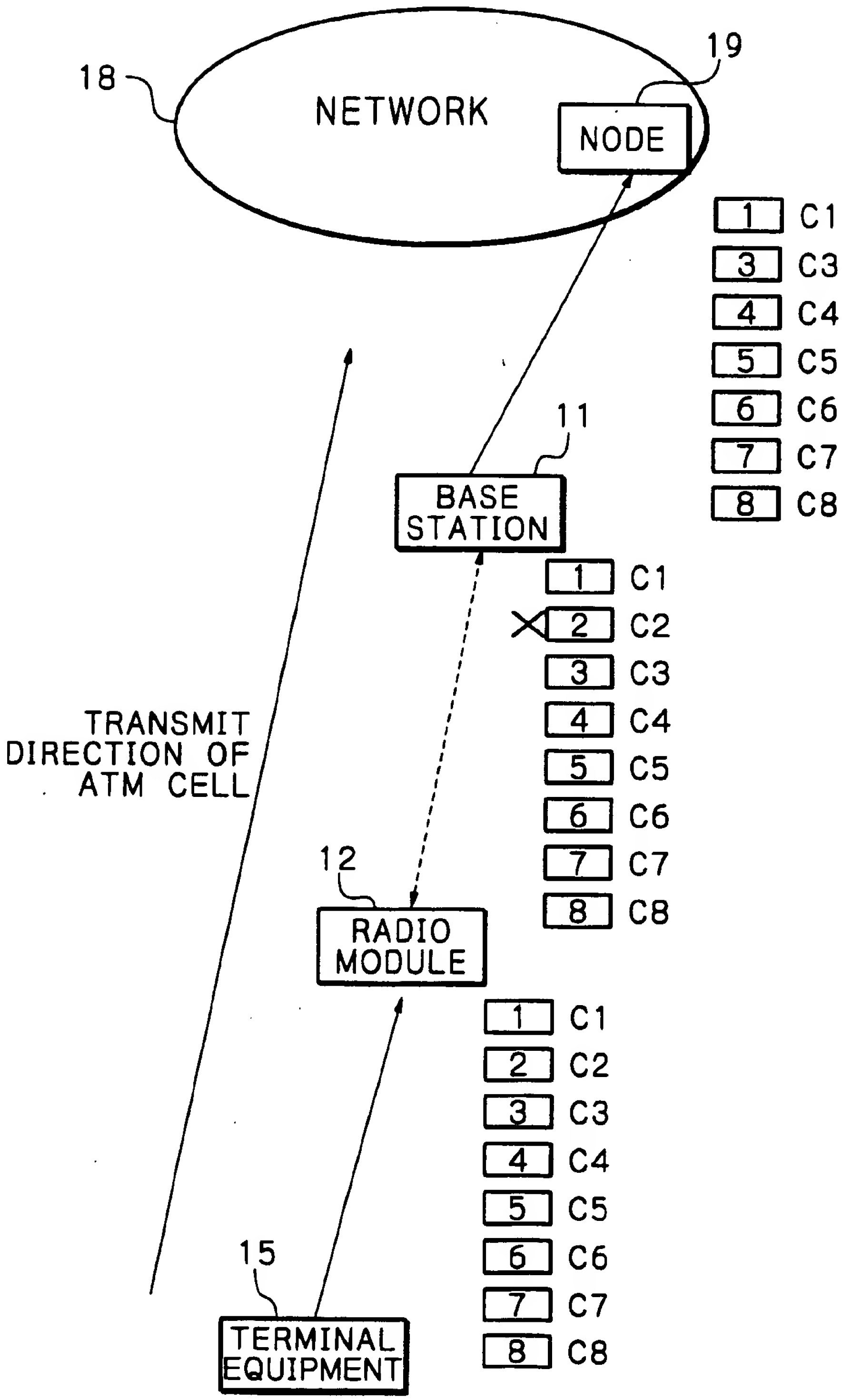


Fig. 14 PRIOR ART

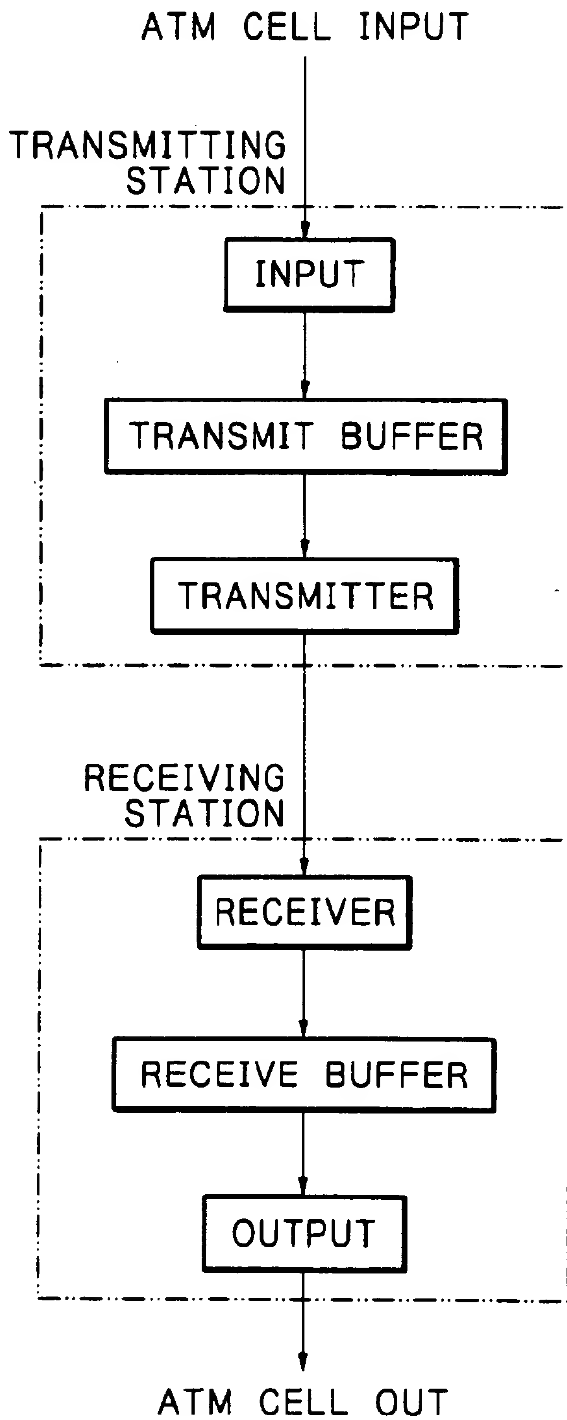
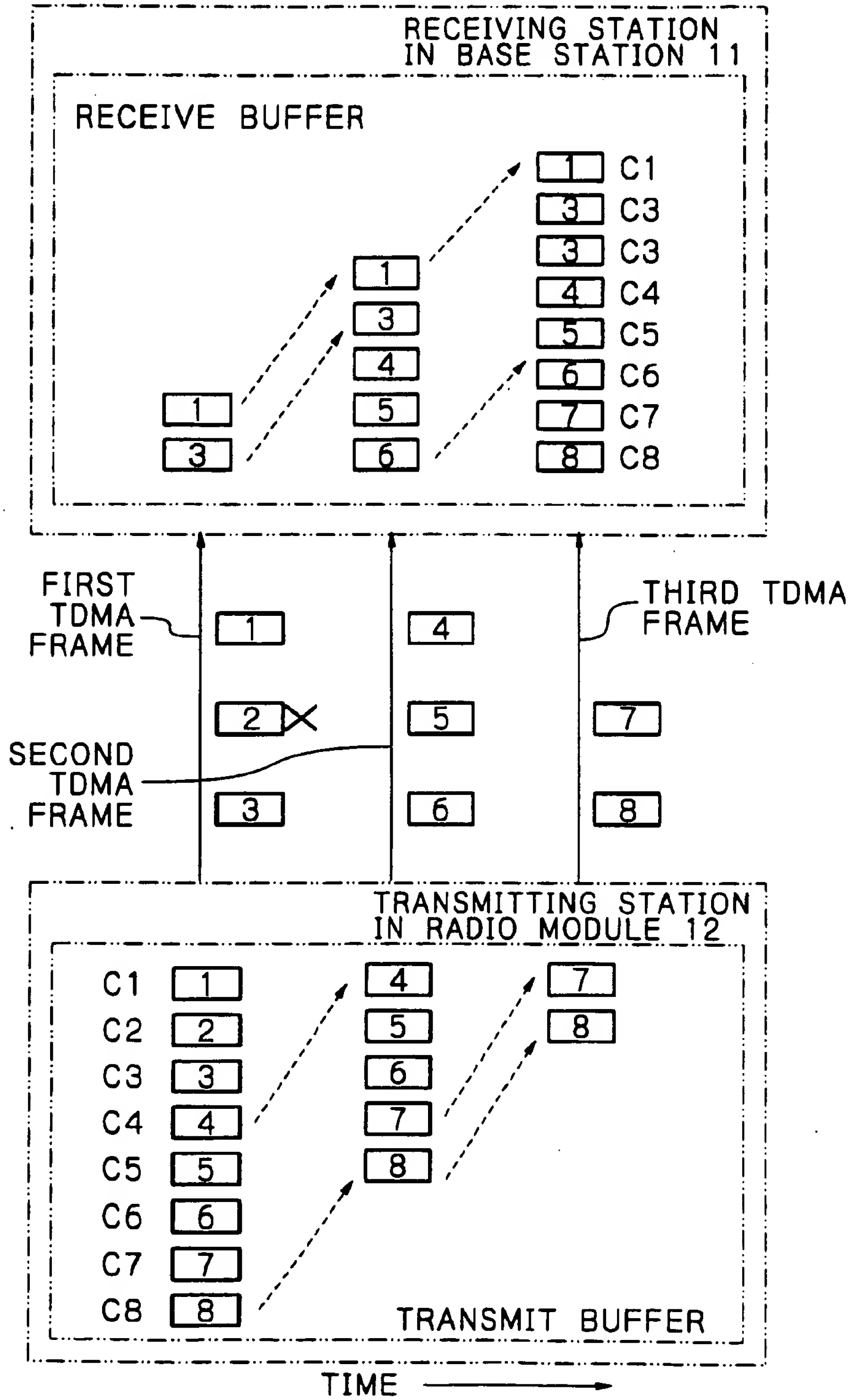


Fig. 15 PRIOR ART



ATM TRANSMISSION SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates to an ATM (Asynchronous Transfer mode) transmission system for transmitting an ATM cell through a radio channel or a wired channel, in particular, relates to such a system which uses a communication channel with high efficiency and suppresses useless traffic.

In an ATM transmission system, a data is transmitted by using an ATM cell which has a fixed length of data. An ATM cell has generally 53 bytes data including a cell header having 5 bytes followed by an information field having 48 bytes, as shown in FIG. 5.

Since an ATM cell has fixed length, high speed data transmission is possible by repetition of relatively simple process.

In an ATM transmission system, an ATM cell is repeated by a node which is called an ATM switch so that the ATM cell is transmitted from a source terminal equipment to a destination terminal equipment. Assuming that an ATM switch has the function to discard a wrong ATM cell (as shown in Japanese patent laid open publication 163141/1996), when there is something wrong in an ATM cell, such as a queue of an ATM cell and/or overflow of a buffer memory, a useless traffic may be suppressed for a transmission line at an output side of the ATM switch, however, no transmission is suppressed in a transmission line at an input side of the ATM switch.

Further, in a prior art, the discard of an ATM cell is triggered by a long queue of an ATM cell in an ATM switch and an overflow of a buffer memory, but not by a transmission error of an ATM cell. A transmission error occurs with high probability in case of a wireless transmission line.

FIG. 11 shows a basic system structure of a wireless ATM system. In FIG. 11, the numeral 11 shows a base station, 12, 13 and 14 are a radio module, 15, 16 and 17 are a terminal equipment, and 18 shows a network.

In FIG. 11, the base station 11 is coupled with radio modules 12–14 through a wireless channel. Each of radio modules 12–14 is connected to a related terminal equipment 15–17. Further, the base station 11 is coupled with the network 18 through an optical fiber, or a metal cable.

The terminal equipment 15–17 and the network 18 carry out transmission and reception of data by using an ATM cell, which is the minimum unit of data to be transmitted.

FIG. 12 shows a protocol stack concerning a user plane (U plane) of a wireless ATM system of FIG. 11. The base station 11 is coupled with the network 18 through a node 19.

As shown in FIG. 12, the protocol of the terminal equipment 15–17 comprises a physical layer (PHY), an ATM layer (ATM), an ATM adaptation layer (AAL), and an application layer (AP). Each of the radio modules 12–14 and the base station 11 has the protocol comprising a physical layer (PHY), an ATM layer (ATM), a wireless layer (Wireless), a data link layer (DLC), and a media access control layer (MAC). The node 19 has a physical layer (PHY) and an ATM layer (ATM).

As for a U plane of the base station 11 and the radio modules 12–14, a layer higher than an ATM adaptation layer (AAL) is not terminated. The terminal equipment 15–17 are seamlessly coupled with the node 19 in the network 18 through the ATM layer (ATM). In a wireless channel between the base station 11 and the radio modules 12–14, a plurality of virtual paths (VP) and virtual channels (VC) which are a logical link of an ATM layer may exist.

FIG. 13 shows a flow of an ATM cell C1–C8 when a terminal equipment 15 transmits a network 18 a data, in a wireless ATM system in FIG. 11. In the embodiment of FIG. 13, a radio module 12 is a transmitter, a base station 11 is a receiver, and the terminal 15 is sending an ATM cell.

As shown in FIG. 13, it is assumed that the terminal 15 sends ATM cells C1 through C8 sequentially to the radio module 12, and that the second ATM cell C2 is erroneous in the wireless section between the radio module 12 and the base station 11, so that the base station 11 receives the first ATM cell C1 and the ATM cells C3 through C8. Then, the base station 11 sends the first ATM cell C1 and the cells C3 through C8 to the network 18.

A base station 11 and a radio module 12 have a transmitting station and a receiving station as shown in FIG. 14. A transmitting station comprises an input means for accepting an ATM cell, a transmit buffer, and a transmit means. The transmit buffer stores temporarily an ATM cell which is in the queue for transmission. A receiving station comprises a receive means, a receive buffer, and an output means. An ATM cell received by the receive means is stored temporarily in the receive buffer. An ATM cell is read out of the receive buffer when requested, and is transmitted through the output means.

FIG. 15 shows the transfer sequence of the ATM cells C1 through C8 in the wireless section in case of FIG. 13. In FIG. 15, a TDMA (Time Division Multiple Access) system is used in wireless data communication between a radio module 12 and a base station 11, and each TDMA frame includes three ATM cells.

In FIG. 15, when cells in a first TDMA frame are transmitted, a first through third ATM cells C1–C3 are transmitted. It is assumed that a second ATM cell C2 is erroneous in a wireless section. Therefore, the base station 11 receives only the first ATM cell C1 and the third ATM cell C3.

When the ATM cell in the first TDMA frame has been transmitted, the radio module 12 has five ATM cells C4, C5, C6, C7 and C8 in the transmit buffer. The fourth through sixth ATM cells C4–C6 are transmitted when the cells in the second TDMA frame is transmitted. Then, the base station 11 has five ATM cells C1, C3, C4, C5 and C6 in the receive buffer.

When the ATM cells in the second TDMA frame has been transmitted, the radio module 12 has two ATM cells C7 and C8 in the transmit buffer. Those two cells C7 and C8 are transmitted when the ATM cells in the third TDMA frame are transmitted.

As a result, the base station 11 receives seven ATM cells C1, C3, C4, C5, C6, C7 and C8. Then, the base station transmits the network 18 seven ATM cells C1, C3, C4, C5, C6, C7 and C8.

By the way, the recent network which uses an ATM communication system, can provide a variety of services. And, for instance, it is requested that a user terminal is seamlessly coupled with an ATM network including wireless means, in other words, it is requested that a user terminal is coupled with a network only through an ATM layer.

However, it should be noted that an ATM cell is erroneous with relatively high probability in a wireless communication section.

In a data communication service which uses an ATM system, a TCP/IP protocol is used in a higher layer. The

communication using the TCP/IP protocol is implemented for instance by a standardized specification (IP over ATM; RFC 1483). In this case, AAL type **5** is used as an ATM adaptation layer (AAL).

In a data communication system using the AAL type **5** as the ATM adaptation layer, the size of a packet in a higher layer is generally larger than the data size (48 bytes) of an information field of an ATM cell, therefore, a packet in a higher layer is segmented to a plurality of ATM cells for transmission.

If an ATM cell or a plurality of ATM cells are in error in transmission, and an error correction by a destination terminal (forward error correction; FEC) can not recover a packet data, when a packet is transmitted in a plurality of ATM cells, then, a packet itself is in error, and it is dealt as a useless packet.

When re-transmission is carried out in a higher layer, the re-transmission of a whole packet must be carried out when only one ATM cell is erroneous. In this case, when a wireless section exists in a network, the probability of a non-useful packet might be relatively high, since the probability of an error of an ATM cell in a wireless section is high.

As described above, when an erroneous ATM cell is included in a packet which has a plurality of ATM cells, a whole packet must be discarded as a non-useless packet. Therefore, even correct ATM cells included in an erroneous packet might be discarded. The transmission of correct ATM cells which are to be discarded because of an erroneous ATM cell in the packet decreases the traffic efficiency in a communication line.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a new and improved ATM transmission system by overcoming the limitations and disadvantages of a prior ATM transmission system.

It is also an object of the present invention to provide an ATM transmission system which suppresses useless traffic.

The above and other objects are attained by an ATM transmission system comprising a transmitting station, a receiving station, a communication channel between said stations for transmitting an ATM cell, data communication with a protocol data unit (PDU) having a packet and a header being carried out by using an ATM adaptation layer (AAL) which can recognize an end of packet cell (EOP cell) in a PDU by referring to a header in said EOP cell, and a plurality of ATM cells which form said protocol data unit being continuously applied to said transmitting station; wherein said receiving station comprises; an error detection means for detection whether an ATM cell is received correctly or incorrectly or lost; a cell arrival informing means for informing the transmitting station the result of said detection; said transmitting station comprises; a transmit buffer for temporarily storing an ATM cell to be transmitted; a group handling means for handling a plurality of ATM cells which form a protocol data unit in a common convergence sublayer as one group; a receiving means of a said cell arrival information whether the ATM cell has been received correctly or incorrectly or lost from an associated receiving station; a group data discard means for discarding all the ATM cells belonging to the group which includes an incorrectly received or lost ATM cell stored in said transmit buffer, when said receiving means receives the information of an incorrectly received or lost ATM cell; an end of packet cell (EOP cell) transmitting means for transmitting an EOP cell which has a flag in a payload type field in an ATM cell header, said flag indicating that the EOP cell is a final cell in the protocol data unit of the group, when said group data discard means discards the ATM cell in said transmit buffer; an ATM cell discard means for discarding an ATM cell which belongs to the discarded group, and arrives after discard.

Preferably, said transmitting station further comprises means for attaching sequence number to each ATM cell to be transmitted, and said error detection means in said receiving station detects whether a cell is received or lost by checking a sequence number of a received ATM cell.

Preferably, a communication channel between a transmitting station and a receiving station includes a plurality of virtual channels; each virtual channel transmits ATM cells having different virtual path identifier and different virtual channel identifier; a transmitting station and a receiving station establish a logical transmission link for each virtual channel of an ATM layer; and said group handling means handles transmission and reception of an ATM cell for each established logical transmission link independently.

Preferably, a communication channel between a transmitting station and a receiving station includes a plurality of virtual channels; each virtual channel transmits ATM cells having different virtual path identifier and different virtual channel identifier; said receiving station comprises a sequence number informing means for informing sequence number of an ATM cell which is lost or wrongly received, to said transmitting station; said transmitting station comprises a table having relations between sequence number of an ATM cell and a group which said ATM cell belongs, and a group identify means for identifying a group which a wrongly received or lost ATM cell belongs, according to a sequence number informed by said receiving means and content of said table.

According to the present invention, in case there is one virtual channel, or a plurality of virtual channels, on a circuit, when an ATM cell which is a part of a protocol data unit (PDU) is consecutively applied to a transmitting station, the transmitting station decides an ATM cell which would be useless, and discards the same.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features, and attendant advantages of the present invention will be appreciated as the same become better understood by means of the following description and accompanying drawings wherein;

FIG. **1** is a block diagram of an ATM transmission system having a transmitting station **100** and a receiving station **200** installed in a base station **11** and a radio module **12**,

FIG. **2** is a flow chart showing the operation of a transmitting station **100** and a receiving station **200** in FIG. **1**,

FIG. **3** shows sequence of transmission of an ATM cell between a transmitting station **100** and a receiving station **200**,

FIG. **4** shows a flow of an ATM cell from a terminal **15** to a node **19** in a wireless ATM transmission system,

FIG. **5** shows a format of an ATM cell,

FIG. **6** is a block diagram of an ATM transmission system in another embodiment,

FIG. **7** is a block diagram of an ATM transmission system in still another embodiment,

FIG. **8** is a block diagram of an ATM transmission system in still another embodiment,

FIG. **9** shows structure of a logical link when a plurality of virtual channels exist,

FIG. 10 shows a flow of ATM cells when ATM cells in a plurality of logical links are mixed and transmitted,

FIG. 11 is a block diagram of a wireless ATM system,

FIG. 12 shows a protocol stack in a wireless ATM system in FIG. 11,

FIG. 13 shows an example of transmission of ATM cells,

FIG. 14 is a block diagram of a prior ATM transmission system, and

FIG. 15 shows an example of transmission of ATM cells in a prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The embodiments are exampled in case a transmission line is a wireless transmission line. Of course, it should be noted that the present invention is applicable not only to a wireless transmission line but also any other transmission line.

First Embodiment

First embodiment of the present invention is described in accordance with FIGS. 1–5.

FIG. 1 is a block diagram of a transmitting station **100** and a receiving station **200**, installed in a base station **11** and a radio module **12**, in a wireless ATM system.

FIG. 2 shows an operational flow of the transmitting station **100** and the receiving station **200** in FIG. 1. FIG. 3 shows the sequence of transmission of an ATM cell in a transmitting station **100** and a receiving station **200**. FIG. 4 shows a flow of an ATM cell from a terminal **15** to a node **19** in the present ATM system. FIG. 5 shows a format of an ATM cell.

As shown in FIG. 4, the wireless ATM system according to the present invention comprises a base station **11**, a radio module **12**, a terminal **15**, a network **18** and a node **19**. In order to establish a wireless link between a base station **11** and a radio module **12**, each of the base station **11** and the radio module **12** has a transmitting station **100** and a receiving station **200**.

In FIG. 1, the transmitting station **100** comprises an input means **101**, a transmit buffer **102**, a transmitter **103**, receiver **104**, a transmit cell management process **105**, and a EOP cell (an End Of Packet cell) generator **106**. The receiving station **200** comprises a receiver **201**, a receive buffer **202**, an output means **203**, a receive cell management process **204**, and a transmitter **205**.

An ATM cell applied to the transmitting station **100** is stored temporarily in the transmit buffer **102** through the input means **101**. The ATM cell stored in the transmit buffer **102** is read out sequentially when requested, and is transmitted from the transmitter **103** towards the receiving station **200** through a wireless link. In an actual embodiment, a slot in a TDMA frame is used to carry one or a plurality of ATM cells.

An ATM cell received by the receiving station **200** in a base station **11** is temporarily stored in a receive buffer **202**, then, it is read out when requested, and is forwarded to a node **19** through an output means **203**.

It is assumed that a type **5** of an ATM adaptation layer (AAL) is used to transmit a packet data, in the present wireless ATM transmission system. In the type **5** of the ATM adaptation layer, a data is processed by each protocol data unit (PDU), which has a packet data and a packet header.

It is further assumed that size of a unit packet (PDU) processed in a higher layer is larger than size of an ATM cell. In this case, each packet is transmitted after segmented into a plurality of ATM cells. Therefore, a plurality of ATM cells are applied to the transmitting station **100** sequentially.

It is one of the features of the present invention that when a plurality of ATM cells are applied to the transmitting station **100**, the transmitting station detects useless ATM cell and discards the same.

In a type **5** of an ATM adaptation layer (AAL), the transmitting station **100** refers to a field of payload type (PT) and a field of virtual path identifier (VPI) and a virtual channel identifier (VCI) in an ATM cell header, and handles a packet having a plurality of ATM cells which consist a common part convergence sub-layer protocol data unit (CPCS-PDU) (see FIG. **5**).

Therefore, the transmitting station **100** treats a plurality of ATM cells to as a group, and processes ATM cells by each packet (or group) which belongs to a higher layer, however, the higher layer is not terminated, in other words, an ATM cell is transmitted only through an ATM layer but not a higher layer. This means in a logical link (VPI, VCI) that a payload type (PT) field is used to detect an ATM cell located at a border of a packet or common part convergence sublayer protocal data unit (CPCS-PDU) in a type **5** of ATM adaptation layer (AAL).

In FIG. **1**, the receive cell management process **204** in the receiving station **200** detects whether an ATM cell from the transmitting station **100** is successfully received or not. When it is successful, the receive cell management process **204** forwards a positive response ACK which shows the successful reception to the transmitting station **100** through a transmitter **205**. When it is failed, the receive cell management process **204** forwards a negative response NAK which shows the fail to the transmitting station **100** through a transmitter **205**.

The receiver **104** in the transmitting station **100** receives a response ACK or NAK which the transmitter **205** in the receiving station **200** forwards, and is transferred to a transmit cell management process **105**.

The transmit cell management process **105** refers to a field of payload type (PT) and a field of virtual path identifier and a virtual channel identifier (VPI, VCI) in an ATM cell header, and handles a plurality of ATM cells which consist a packet (CPCS-PDU) as a group.

When the transmit cell process **105** detects a failed ATM cell by the NAK from the receiver **104**, all the ATM cells in the group (including untransmitted CPCS-PDU) including the failed ATM cell are discarded from the transmit buffer **102**.

When the transmit cell management process **105** discards an ATM cell in the transmit buffer **102**, an EOP (end of packet) cell generator **106** generates an EOP cell, which is transmitted to the receiving station **200** through the transmit buffer **102** and the transmitter **103**.

An EOP cell generated by the EOP cell generator **106** has the same identifiers (VPI, VCI) of a virtual link as that of the discarded ATM cell, and a bit (SDU type) is set to 1 (one) in a payload type (PT) field, in order to indicate that the EOP cell is the border or the final ATM cell in the packet.

A destination terminal equipment of the packet can recognize that all the ATM cells in a packet (CPCS-PDU) has completed, upon receipt of an EOP cell.

FIG. **2** shows the operational flow of the transmitting station **100** and the receiving station **200**.

The transmit cell management process **105** in the transmitting station **100** groups (S10) a plurality of ATM cells of

a packet (CPCS-PDU) by referring each fields (PT, VCI, VPI) in an ATM cell header, upon receipt of an ATM cell into the transmit buffer 102 through the terminal 15 or node 18.

If an ATM cell belongs to a group which has been discarded (S10A), the ATM cells which belong to the discarded group are discarded (S10B).

When an ATM cell does not belong to a group which has been discarded, the transmitting station 100 transmits an ATM cell by a TDMA frame according to an assigned radio resource to the receiving station 200 (S11).

Then, the transmitting station 100 receives the response ACK or NAK for the transmitted ATM cells from the receiving station 200 through a control wireless channel (S12).

When no NAK is received, that is to say, when the transmission of an ATM cell is successful, the transmit cell management process 105 deletes transmitted ATM cells in the transmit buffer 102 (S14). Alternatively, the transmit cell management process 105 may delete a transmitted ATM cell in the transmit buffer 102 immediately when an ATM cell has been transmitted, with no reception of response (ACK or NAK).

When there is an untransmitted ATM cell in the transmit buffer 102, the control returns to the step S11 so that the transmission of ATM cell is continued. When all the ATM cells in the transmit buffer 102 are transmitted, the transmit process finishes.

When the transmitting station 100 receives the negative response NAK for a transmitted ATM cell from the receiving station 200, the control proceeds to the step S16, and the transmit cell management process 105 discards all the ATM cells belonging to the group including the failed ATM cell in the transmit buffer.

In the step S17, an EOP cell generated by the EOP cell generator 106 is transmitted to the receiving station 200. The EOP cell itself is an ATM cell, which has one bit (SDU type) set to 1 in a PT field in a cell header.

When the receiving station 200 receives an ATM cell, the receive cell management process 204 checks whether it is successful or in fail (S20). When it is successful, the positive response ACK is sent to the transmitting station (S21), and when it is failure, the negative response NAK is sent to the transmitting station (S22).

An ATM cell which is received successfully is forwarded to a node 19 or a terminal 15 (S23).

FIG. 3 shows an operation of transmission of an ATM cell from the transmitting station 100 to the receiving station 200 through a wireless section. It is supposed that a wireless information channel is provided between the transmitting station 100 and the receiving station 200, and a wireless control channel is also provided for transmission of the result of the user information.

In FIG. 3, it is assumed that each TDMA frame can transmit three ATM cells, for the sake of simplicity of explanation. It is also assumed that each packet (PDU) has 8 ATM cells C1 through C8, and the second ATM cell C2 is erroneous in a wireless link. In FIG. 3, the change of the situation is shown in the horizontal direction from left to right.

An ATM cell which is to be transmitted from the transmitting station 100 to the receiving station 200 is kept in a transmit buffer. In the embodiment, 8 ATM cells C1 through C8 are kept in the transmit buffer 102.

First, three ATM cells C1 through C3 among 8 cells C1 through C8 are transmitted in the first TDMA frame.

After the transmission of three cells C1 through C3, 5 cells C4 through C8 are kept in the transmit buffer 102.

When the second ATM cell C2 is erroneous in a wireless link in the first TDMA frame, the receiving station 200 detects the error, and sends the negative response NAK to the transmitting station 100.

The transmitting station 100 recognizes the error upon receipt of the response NAK from the receiving station 200. Then, the transmitting station 100 discards the ATM cells C4 through C8 kept in the transmit buffer 102 as a useless cell.

Further, the transmitting station 100 generates an EOP cell CD, which is transmitted to the receiving station 200 in the next TDMA frame.

The EOP cell CD is an ATM cell which informs a destination receiver an end of a packet (PDU). It is supposed that a EOP cell CD has a bit (SDU type) set to 1 (one) in a PT field in a cell header.

As a result, the destination receiver receives two ATM cells C1 and C3, and an EOP cell CD in a packet (PDU).

It should be noted that a packet which includes a wrong ATM cell has less ATM cells in the present invention than a number of initially transmitted ATM cells. Therefore, the traffic is decreased according to the present invention as compared with the case that all the ATM cells C1 through C8 were transmitted.

FIG. 4 shows a flow of an ATM cell when a packet (PDU) having 8 ATM cells (C1 through C8) is transmitted from the terminal 15 to the node 19. In FIG. 4, an ATM cell is transmitted by using a transmitting station 100 installed in a radio module (RM) 12 and a receiving station 200 installed in a base station 11.

When the second ATM cell C2 is in error in wireless link between a radio module 12 and a base station 11, as is the case of FIG. 3, the radio module 12 transmits an EOP cell CD after three ATM cells C1 through C3 are transmitted to the base station 11.

Accordingly, the base station 11 transfers the received ATM cells C1, C3 and an EOP cell CD to a node 19 of a network 18.

Comparing FIG. 4 with FIG. 13 which belongs to a prior art, it should be appreciated that only three ATM cells C1, C3 and CD are sent to a node 19 in FIG. 4 (present invention), while seven ATM cells (C1, C3, C4, C5, C6, C7 and C8) are sent to a node 19 in FIG. 13 (prior art), and that those ATM cells sent to a node 19 are discarded because of lack of C2. The present invention has the advantage that less number of ATM cells are forwarded when an ATM cell in a packet is in error, and thus, the traffic in a communication line is decreased.

The above embodiment is directed that an EOP cell is newly generated after all the cells in a packet are discarded. As a modification, as a packet has inherently an EOP cell which has a bit (SDU type) set to 1 in a PT field, at the end of the packet, it is possible to discard all the cells except the EOP cell in a packet, but no new EOP cell is generated.

Second Embodiment

FIG. 6 shows a block diagram of another embodiment of the present ATM transmission system. In FIG. 6, the same numerals as those of FIG. 1 show the same members, and the same operation as that of FIG. 1 is omitted in the following description.

The feature of the embodiment of FIG. 6 is that a receiving station 200B can detect an error of reception even when an ATM cell is lost in a link between a transmitting station 100B and a receiving station 200B.

As shown in FIG. 6, a transmit cell process **105B** in the transmitting station **100B** has a sequence number attach **107**, which attaches an ATM cell in a transmit buffer **102** a sequence number so that a specific ATM cell is identified.

An ATM cell assigned a sequence number is transmitted to a wireless link through a transmitter **103**.

In a receiving station **200B**, an ATM cell thus received is applied to a receive buffer **202** through a receiver **201**. This ATM cell is applied to a receive cell process **204B** which confirms the safe receipt of the ATM cell, and then, the ATM cell is provided to an external circuit through an output means **203**.

It should be appreciated that the receive cell process **204B** detects not only an error of an ATM cell but also a loss of the same in a wireless link.

An ATM cell applied to the receive cell process **204B** includes an information of sequence number of an ATM cell, therefore, the receive cell process **204B** can confirm the loss of an ATM cell based upon the sequence of the sequence number.

For instance, in FIG. **4**, assuming that the ATM cells C1 through C8 have sequence numbers **0001, 0002, 0003, 0004, 0005, 0006, 0007**, and **0008**, respectively, then, an ATM cell received in the receive cell process **204B** in a base station **11** has the sequence number **0001, 0002, 0003** et al in normal condition.

On the other hand, if the second ATM cell is lost, the third ATM cell having the sequence number **0003** is detected after the first ATM cell having the sequence number **0001**. Thus, the receive cell process **204B** confirms the loss of an ATM cell according to the sequence of the sequence numbers of ATM cells reached the receive cell process **200B**.

The receive cell management process **204B**, upon detection of the loss or the error, transmits the response NAK which indicates the loss or the error to the transmitting station **100B** through the transmitter **205**.

As is the case of the first embodiment of FIG. 1, the transmit cell management process **105B** in the transmitting station **100B** refers to the fields PT, VCI and VPI in the cell header of an ATM cell, handles a plurality of cells which form a packet (CPCS-PDU) as one group.

Upon recognition of the failure of an ATM cell by the negative response NAK from the receiving station **200B**, all the ATM cells belonging to the group which includes the failed cell are discarded in the transmit buffer **102**.

Then, an EOP cell generated in the EOP cell generator **106** is transmitted through the transmit buffer **102** and the transmitter **103**. The cell header of the EOP cell has the same information in the fields VPI and VCI in the cell header as those of the discarded ATM cell. The bit SDU type in the field PT of the EOP cell is set to 1 (one).

Third Embodiment

FIG. **7** shows a block diagram of still another embodiment of the present wireless transmission system. The same numerals as those of the previous embodiments show the same members. The operation of FIG. **7** which is not described is the same as that of the previous embodiments.

It is assumed in FIG. **7** that a plurality of virtual channels are provided between a terminal **15** and a node **19** as shown in FIG. **9**. In this case, ATM cells having different virtual channels (VPI/VCI) exist simultaneously in a wireless link.

In this case, logical transmission links L1, L2 are assumed for each virtual channels between the transmitting station **100C** and the receiving station **200C**, and the transmission and/or the reception of an ATM cell is processed for each logical transmission links L1 and L2. Thus, even when ATM cells having the different virtual channels (VPI/VCI) exist, the transmitting station **100C** can discard a useless ATM cell.

In FIG. **9**, a wired link **53** is provided between a terminal **15** and a radio module **12**. A radio module **12** and a base station **11** are coupled by a wireless user link **58** and wireless control link **59**. Further, a base station **11** is coupled with a node **19** by a wired link **63**.

It is assumed that two virtual channels **51** and **52** are provided between the terminal **15** and the radio module **12**, two virtual channels **54** and **55**, and a control link **56** are provided between the radio module **12** and the base station **11**, and two virtual channels **61** and **62** are provided between the base station **11** and the node **19**.

In the virtual channels **51, 54** and **61**, the virtual path identifier VPI is "A" and the virtual channel identifier VCI is "B", and in the virtual channels **52, 55** and **62**, the virtual path identifier VPI is "C", and the virtual channel identifier VCI is "D".

It should be noted that a radio module **12** and a base station **11** do not terminate a virtual channel (VP/VC). It is a design matter of an actual system where a virtual channel is terminated. A radio module **12** and/or a base station **11** can change an identifier (VPI/VCI).

As shown in FIG. **9**, between a radio module **12** and a base station **11**, a wireless user link **58** and a wireless control link **59** for control link **56** are provided.

The response whether an ATM cell reached correctly or not, from the receiving station **200C** to the transmitting station **100C** is transmitted through the control link **56**. Two pairs of virtual channels **51-54-61**, and **52-55-62** are provided between the terminal **15** and the node **19**.

In this embodiment, two kinds of ATM cells, one having a virtual path identifier (VPI) "A" and a virtual channel identifier (VCI) "B", and the other having a virtual path identifier (VPI) "C" and a virtual channel identifier (VCI) "D" exist simultaneously in wired links **53** and **63** and the wireless user link **58**.

It is assumed that an ATM cell is transmitted from a terminal **15** to a node **19**, in other words, a radio module is a transmitting station and a base station is a receiving station.

When an ATM cell which forms a packet is transmitted to a radio module **12** from a terminal **15**, the ATM cell is stored temporarily in a transmit buffer in the radio module **12**. The radio module **12** handles an ATM cell for each virtual channel, and establishes logical transmission links **L1** and **L2** in a user wireless link **58** for each virtual channel between the radio module and the base station **11**.

The base station **11** also handles a receive ATM cell for each virtual channel. The assignment of sequence number to an ATM cell in a radio module, the response or confirmation of receipt of an ATM cell by a base station, are carried out for each logical wireless links L1 and L2, independently.

As described above, even when a plurality of virtual links exist in a wireless circuit, a logical transmission link (L1, L2) is established for each virtual channel between a radio module and a base station, and a sequence number is processed in each logical transmission link, independently. Thus, it is possible to discard a useless ATM cell.

FIG. **7** shows a transmitting station **100C** and a receiving station **200C** when two virtual channels exist, and it should be noted that a transmitting station **100C** has two transmit buffers **102A** and **102B**.

An ATM cell applied to the transmitting station **100C** is stored either in a transmit buffer **102a** or in a transmit buffer **102B** for each virtual channel through an input means **101**. A pair of transmit buffers **102A** and **102B** may be implemented either by a single physical memory which is divided into a plurality of partial areas, or by a plurality of physical memories. Receive buffers **202A** and **202B** may be implemented similarly.

The transmit cell management process **105C** refers to the fields PT, VCI and VPI in an ATM cell header, and processes a plurality of ATM cells which form a packet (CPCS-PDU) as one group.

The sequence number attach **107C** assigns sequence number for confirmation of arrival, and logical wireless link identifier which shows logical wireless link to each ATM cell, for every logical wireless link.

An ATM cell which is assigned sequence number and logical wireless link identifier is radiated into wireless space as a wireless ATM cell through a transmitter **103**. The wireless ATM cell is received by the receiving station **200C**.

The wireless ATM cell received by the receiving station **200C** is applied either to a receiving buffer **202A** or **202B** for every virtual channel through a receiver **201**.

The receive cell management process **204C** in the receiving station **200C** confirms the sequence number of an ATM cell for every logical wireless link, and forwards the positive response ACK for a successful ATM cell or the negative response NAK for a failed ATM cell through the transmitter **205**.

The response ACK or NAK is assigned an information which logical wireless link it belongs by the receive cell process **204C**.

The transmit cell management process **105C** in the transmitting station **100C** receives the response ACK/NAK and logical wireless link information transmitted by the transmitter **205** of the receiving station **200C**, through the receiver **104**.

The transmit cell management process **105C** refers to the fields PT, VCI and VPI in the ATM cell header, and handles plurality of ATM cells which form one packet (CPCS-PDU) as one group.

When the transmit cell management process **105C** detects a wrong ATM cell which fails in transmission, all the ATM cells in the group which includes the wrong ATM cell, are discarded in a transmit buffer **102A** or **102B**.

Then, an EOP cell generated by the EOP cell generator **106C** is transmitted through the transmitter **103**. The virtual path identifier VPI and the virtual channel identifier VCI of the EOP cell are the same as those of discarded ATM cells. The bit SDU of the field PT in the EOP cell is 1 (one).

FIG. **10** shows the flow of an ATM cell when ATM cells belonging to one of two virtual channels is transmitted. In FIG. **10**, it is assumed that an ATM cell is transmitted from a radio module **12** to a base station **11**. In FIG. **10**, a first virtual channel relating to a logical wireless link L1 and a second virtual channel relating to a logical wireless link L2 exist.

It is assumed that 16 ATM cells **C01–C16** are applied to the radio module **12**, among them, 8 ATM cells **C01**, **C04**, **C06**, **C07**, **C12**, **C13**, **C15** and **C16** are transmitted through a first logical transmission link L1, and other 8 ATM cells **C02**, **C03**, **C05**, **C08**, **C09**, **C10**, **C11** and **C14** are transmitted through a second logical transmission link L2.

The 8 ATM cells **C01**, **C04**, **C06**, **C07**, **C12**, **C13**, **C15** and **C16** are obtained by segmenting a packet in an ATM adaptation layer (AAL) type **5**. Also, other 8 ATM cells **C02**, **C03**, **C05**, **C08**, **C09**, **C10**, **C11** and **C14** are obtained by segmenting another packet.

In the wireless ATM transmission system in FIG. **7**, the control of the confirmation of an ATM cell, et al is carried out for every logical transmission link, the ATM cells are transmitted as shown in FIG. **10**.

If there were no error, the 16 ATM cells **C01–C16** would be sequentially transmitted from the radio module to the base station. However, FIG. **10** shows that the second cell **C04** among 8 cells **C01**, **C04**, **C06**, **C07**, **C12**, **C13** **C15** and **C16** which are handled by the logical link L1 is in error.

If the error of the ATM cell **C4** is recognized after the third ATM cell **C06** is transmitted in the logical transmission link L1, the rest of the ATM cells **C07**, **C12**, **C13**, **C15** and **C16** in the logical wireless link L1 are discarded in the transmit buffer **102A**, and instead, an EOP cell CDl is transmitted.

Other 8 ATM cells **C02**, **C03**, **C05**, **C08**, **C09**, **C10**, **C11** and **C14** handled in the other logical transmission link L2 are correctly transmitted with no error, and therefore, all of those cells are transmitted to the base station **11**.

Accordingly, it should be appreciated that when there are ATM cells belonging to different packets each of which is transmitted through an associated virtual channel (VPI/VCI), only untransmitted ATM cells belonging to a packet (group) having an ATM cell with an error are discarded.

Fourth Embodiment

FIG. **8** is a block diagram of still another embodiment of an ATM transmission system according to the present invention.

In FIG. **8**, the same numerals as those in the previous embodiments show the same members, and the operation which is not described in FIG. **8** but described in accordance with the previous embodiments is the same as those of the previous embodiments.

It is assumed in FIG. **8** that a plurality of virtual channels are provided between a terminal **15** and a node **19**, as is the case of the embodiment of FIG. **7**. Therefore, a plurality of ATM cells having the different virtual path identifier VPI and the different virtual channel identifier VCI exist in a wireless channel.

In FIG. **8**, a table **108** is provided in a transmit cell management process **105D**. The table **108** keeps the relations between a sequence number for confirmation of correct arrival of an ATM cell, and a group (packet(PDU)) which includes the ATM cell of said sequence number. The table **108** is always updated.

The transmit cell management process **105D** can identify a group (packet) including an ATM cell which fails in transmission, by the sequence number of the wrongly received or the lost ATM cell from the receiving station **200D**, and the content of the table **108**. Therefore, the transmit cell management process **105D** can discard the rest of the ATM cells which belong to only a packet to be discarded.

This is described in accordance with FIG. **8**. An ATM cell applied to a transmitting station **100D** is applied to a transmit buffer **102** through an input means **101**.

The transmit cell management process **105D** assigns a sequence number for confirming correct arrival to an ATM cell stored in the transmit buffer **102**. Further, the transmit cell management process **105D** refers to the fields PT, VCI and VPI in the header of an ATM cell, so that a plurality of ATM cells belonging to a packet (CPCS-PDU) are handled as one group.

And, the transmit cell management process **105D** writes in the table **108** the relations between a group which shows a specific packet and a sequence number which belongs to said group.

The ATM cell which is assigned a sequence number is transmitted into radio channel as a wireless ATM cell through a transmitter **103**.

The receiving station **200D** receives the wireless ATM cell, and send the same to the receive buffer **202** through the receiver **201**. When the receive cell management process **204D** confirms that the received cell is correct, the ATM cell in the receive buffer **202** is transferred to an external circuit through the output means **203**.

The receive cell management process **204D** sends the response ACK for a successful ATM cell or NAK for a failed ATM cell to the transmitting station **100D** through the transmitter **205**.

The response NAK sent through the transmitter **205** includes the sequence number of the wrongly received ATM cell.

The transmit cell management process **105D** in the transmitting station **100D** receives the response ACK/NAK and the sequence number sent by the receiving station **200D**, through the receiver **104**. The transmit cell management process **105D**, upon detection of wrongly received ATM cell by the response NAK, identifies the group which the wrongly received ATM cell belongs to, based upon the sequence number informed by the receiving station **200D**, and the data stored in the table **108**.

Then, the transmit cell management process **105D** discards all the ATM cells in the group which the wrongly received ATM cell belongs to, stored in the transmit buffer **102**.

Then, an EOP cell generated by the EOP cell generator **106C** is transmitted to the receiving station **200D** through the transmitter **103**. The EOP cell has the same data in the fileds PT, VPI and VCI as the corresponding data of the discarded ATM cell, but the bit SDU in the field PT of the EOP cell is 1 (one).

Effect of the Invention

As described above in detail, according to the present invention, an ATM cell which would be useless in a destination terminal equipment is found in a transmitting station, and is discarded with no transmission. Thus, the effective use of radio resource is obtained, as the transmission of useless ATM cell into radio channel is suppressed. Further, no useless traffic is applied to a network and/or a terminal.

Further, the present invention is available when a plurality of virtual channels (VP/VC) exist in a wireless circuit.

As mentioned above in detail, the present invention is advantageous when it is used in a wireless transmission circuit which has undesired large probability of error, and restricted bandwidth.

Of course, the present invention may be used not only in a wireless transmission circuit, but also a wired circuit.

Further, according to the present invention, when a transmitting station detects an ATM cell which is to be useless, no higher layer is terminated, but only an ATM layer. Thus, an apparatus may be small and control of the same is simplified.

As mentioned above in detail, an improved ATM transmission system has been found. It should be understood of course that the embodiments disclosed are merely illustrative and are not intended to limit the scope of the invention. Reference should be made, therefore, to the appended claims to find the scope of the invention.

What is claimed is:

1. An ATM transmission system comprising a transmitting station, a receiving station, a communication channel between said stations for transmitting an ATM cell, data communication with a protocol data unit (PDU) having a packet and a header being carried out by using an ATM adaptation layer (AAL) which can recognize an end of packet cell (EOP cell) in a PDU by referring to a header in said EOP cell, and a plurality of ATM cells which form said protocol data unit being continuously applied to said transmitting station,

wherein

said receiving station comprises;

an error detection means for detection whether an ATM cell is received correctly or wrongly,

a cell arrival informing means for informing the transmitting station the result of said detection,

said transmitting station comprises;

a transmit buffer for temporarily storing an ATM cell to be transmitted,

a group handling means for handling a plurality of ATM cells which form a protocol data unit in a common convergence sublayer as one group,

a receiving means of a said cell arrival information whether the ATM cell has been received correctly or wrongly from an associated receiving station,

a group data discard means for discarding all the ATM cells belonging to the group which includes a wrongly received ATM cell stored in said transmit buffer, when said receiving means receives the information of a wrongly received ATM cell,

an end of packet ATM cell (EOP cell) transmitting means for transmitting an EOP cell which has a flag in a payload type field in an ATM cell header, said flag indicating that the EOP cell is a final ATM cell in the protocol data unit of the group, when said group data discard means discards an ATM cell in said transmit buffer,

an ATM cell discard means for discarding an ATM cell which belongs to the discarded group and which arrives discard.

2. An ATM transmission system according to claim **1**, wherein said transmitting station further comprises means for attaching sequence number to each ATM cell to be transmitted, and said error detection means in said receiving station detects whether a cell is received or lost by checking a sequence number of a received ATM cell.

3. An ATM transmission system according to claim **2**, wherein

a communication channel between a transmitting station and a receiving station includes a plurality of virtual channels,

each virtual channel transmits ATM cells having different virtual path identifier and different virtual channel identifier,

a transmitting station and a receiving station establish a logical transmission link for each virtual channel of an ATM layer, and

said group handling means handles transmission and reception of an ATM cell for each established logical transmission link independently.

4. An ATM transmission system according to claim **2**, wherein

a communication channel between a transmitting station and a receiving station includes a plurality of virtual channels,

each virtual channel transmits ATM cells having different virtual path identifier and different virtual channel identifier,

said receiving station comprises a sequence number informing means for informing sequence number of an ATM cell which is lost or wrongly received, to said transmitting station,

said transmitting station comprises a table having relations between sequence number of an ATM cell and a group which said ATM cell belongs, and a group identify means for identifying a group which a wrongly received or lost ATM cell belongs, according to a sequence number informed by said receiving means and content of said table.

5. An ATM transmission system according to one of claims 1–4, wherein said transmitting station is a wireless transmitting station, and said receiving station is a wireless receiving station.

* * * * *

US005729536A

United States Patent [19]

Doshi et al.

[11] Patent Number: 5,729,536

[45] Date of Patent: Mar. 17, 1998

[54] **CELLULAR SYSTEM ARCHITECTURES SUPPORTING DATA SERVICES**

[75] Inventors: **Bharat Tarachand Doshi**, Holmdel; **Subrahmanyam Dravida**, Freehold, both of N.J.; **Richard Paul Ejzak**, Wheaton, Ill.; **Sanjiv Nanda**, Plainsboro, N.J.; **Anil Sawkar**, Bedminster, N.J.; **Philip Andrew Treventi**, Murray Hill, N.J.

[73] Assignee: **Lucent Technologies**, Murray Hill, N.J.

[21] Appl. No.: **630,147**

[22] Filed: **Apr. 10, 1996**

[51] Int. Cl.^{6} **H04Q 7/28**

[52] U.S. Cl. **370/328**; 970/335; 970/337; 970/395

[58] **Field of Search** 370/389, 395, 370/396, 397, 398, 399, 400, 409, 352–357, 321, 335, 337, 342, 347, 441, 442, 264, 524; 455/33.1, 33.2, 422, 328; 379/59, 60

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,406,550	4/1995	McTiffin	370/395
5,434,853	7/1995	Hemmady et al.	370/395
5,438,565	8/1995	Hemmady et al.	370/395
5,539,744	7/1996	Chu et al.	455/33.2
5,541,917	7/1996	Farris et al.	379/220

OTHER PUBLICATIONS

"An Architecture and Methodology for Mobile-Executed Cell Hand-off in Wireless ATM Networks", A.S. Acampora and M. Naghshineh, *IEEE Journal on Selected Areas in Communications*, v. 12, n. 8, Oct. 1994, pp. 1–8.

"A Simple Architecture for Intelligent Multiplexing in a Voice Oriented Tactical ATM Network", Benjamin W. Hoe, *IEEE MILCOM*, v. 2 1994, pp. 490–494.

"Mobile Access to an ATM Network Using a CDMA Air Interface", M.J. McTiffin, et al., *IEEE Journal on Selected Areas in Communications*, vol. 12, No. 5, Jun. 1994, pp. 900–908.

"Supporting User Terminal Mobility Over an ATM-Based Personal Communications Network", Oliver T.W. Yu and Victor C.M. Leung, *IEEE INFOCOM '95*, Jul. 29, 1994.

Primary Examiner—Douglas W. Olms
Assistant Examiner—Ajit Patel

[57] **ABSTRACT**

Four stages of digital cellular architecture are presented which reuse much of the existing voice infrastructure while allowing graceful introduction of data and integrated voice/data services over industry standard, low cost platforms. First, a separate ATM-based infrastructure is introduced that supports data services. A new data call control is introduced on industry standard hardware platforms using object oriented and modular programming. Second, ATM is introduced at radio ports and call control functions are migrated to the new ATM-based call control platforms. Third, vocoders are introduced at the DCS. Fourth, the cellular functions of the legacy cellular switch are phased out and replaced by the ATM-based target architecture.

33 Claims, 6 Drawing Sheets

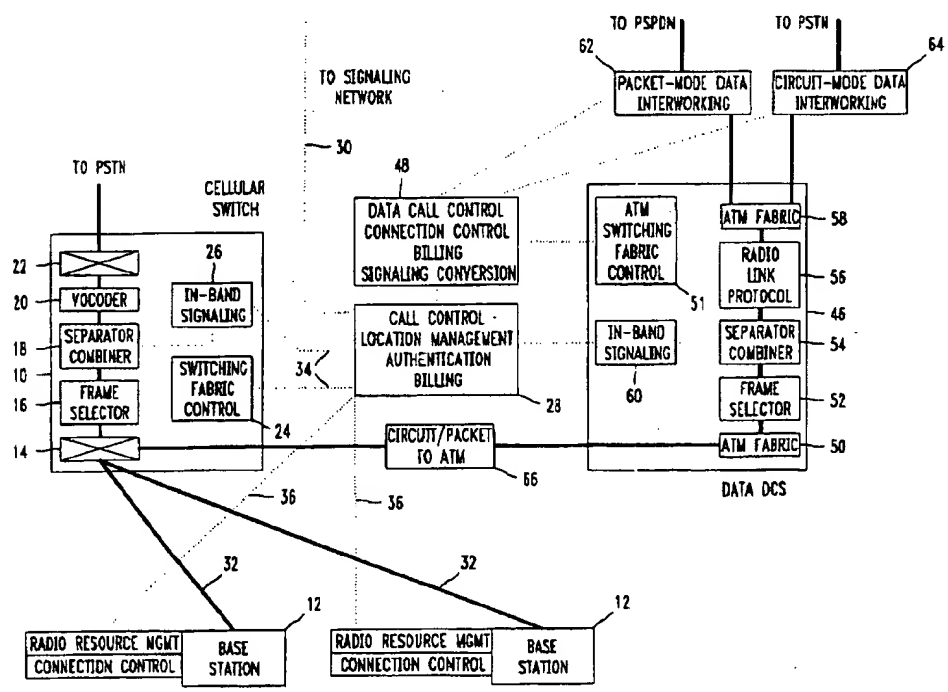


FIG. 1
PRIOR ART

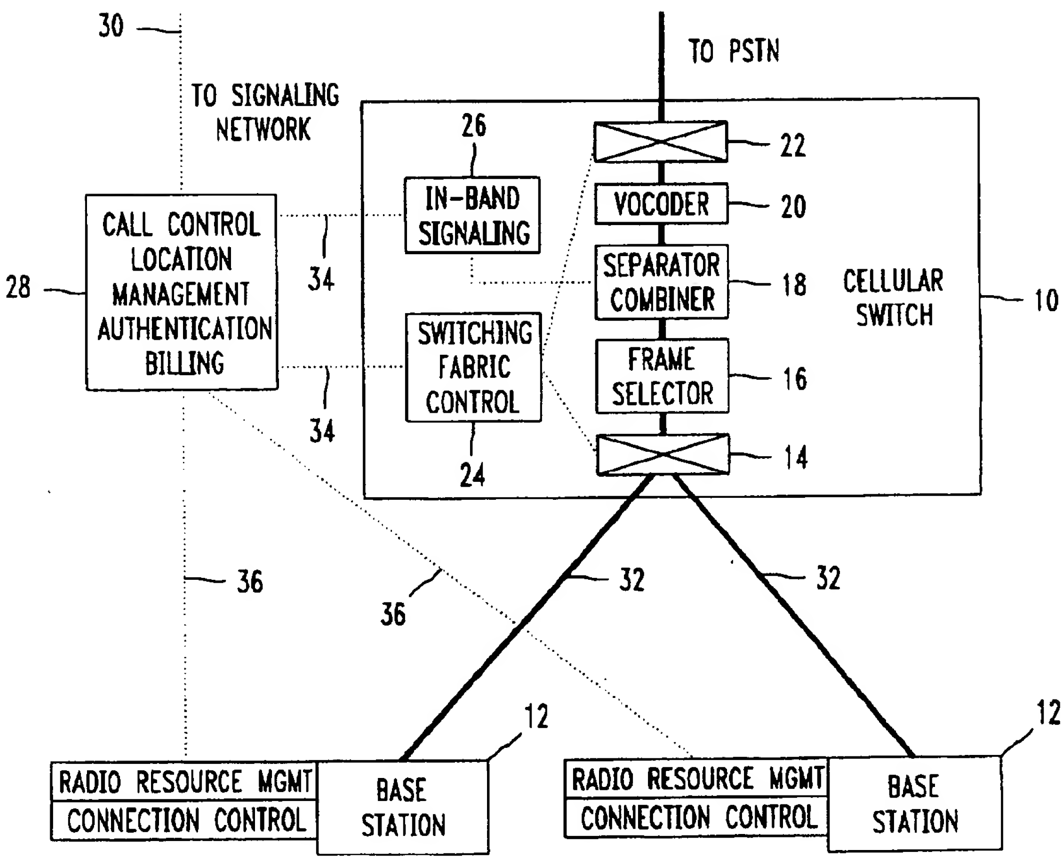
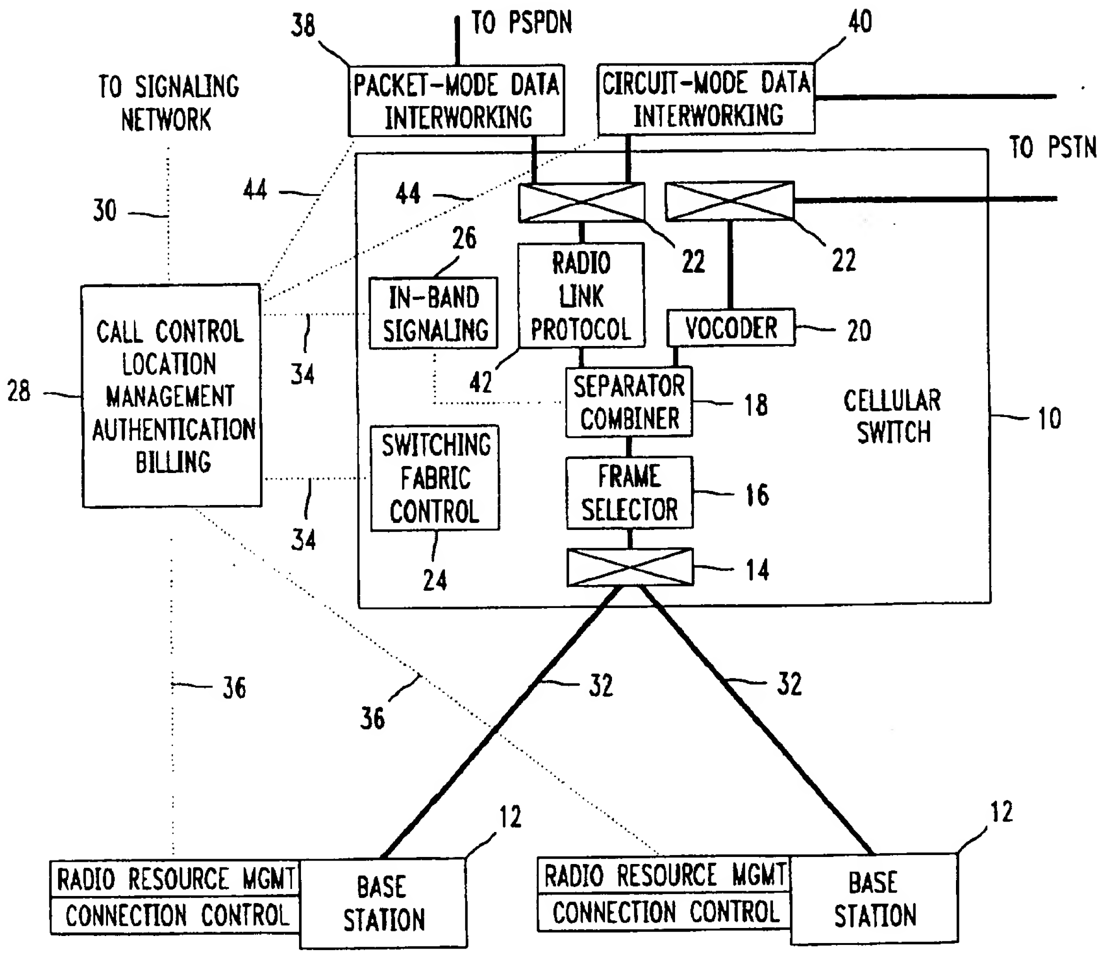


FIG. 2
PRIOR ART



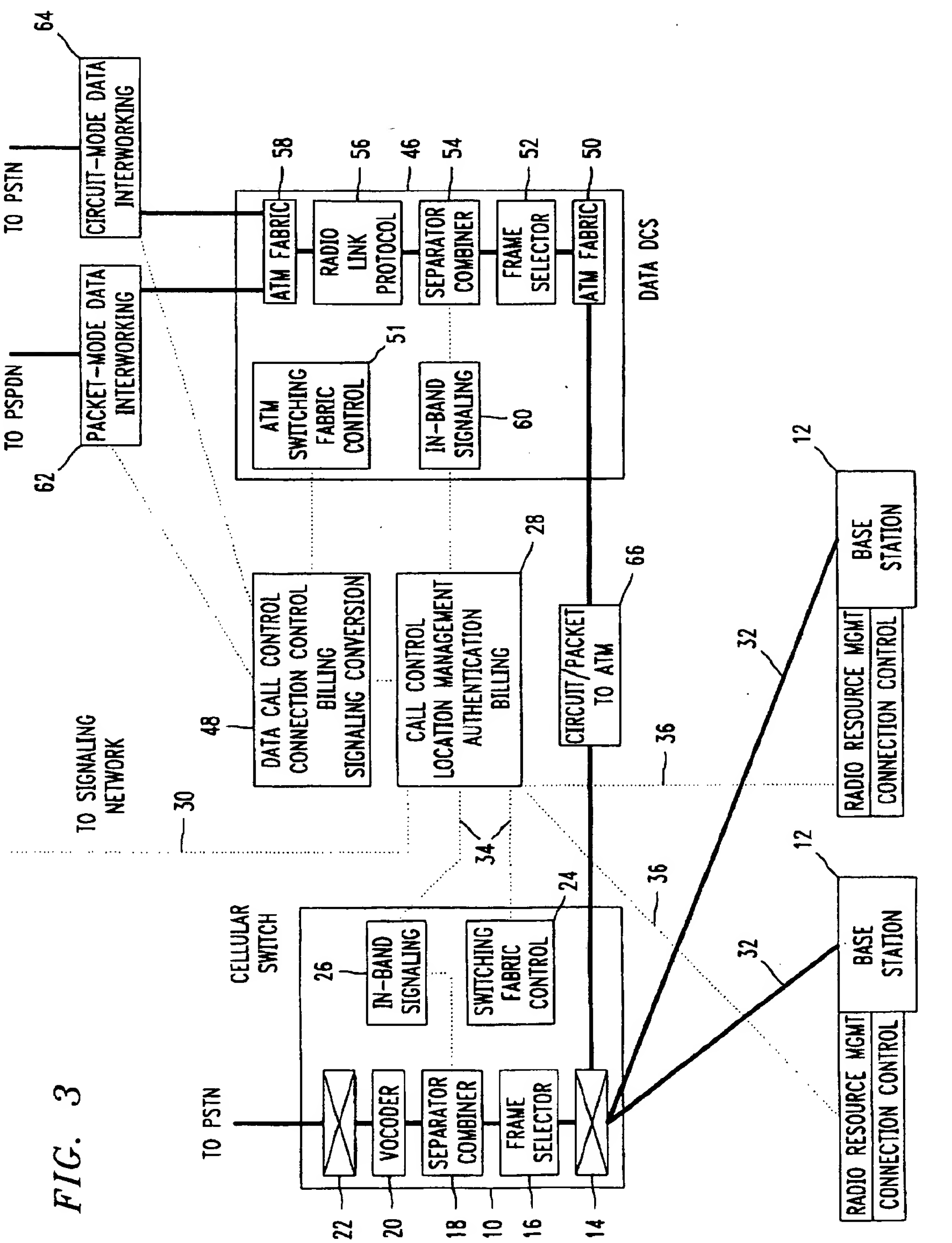

TO PSTN
TO PSPDN
CIRCUIT-MODE DATA INTERWORKING
PACKET-MODE DATA INTERWORKING
64
62
58
56
46
54
52
50
ATM FABRIC
RADIO LINK PROTOCOL
SEPARATOR COMBINER
FRAME SELECTOR
ATM FABRIC
DATA DCS
ATM SWITCHING FABRIC CONTROL
51
IN-BAND SIGNALING
60
DATA CALL CONTROL
CONNECTION CONTROL
BILLING
SIGNALING CONVERSION
48
CALL CONTROL
LOCATION MANAGEMENT
AUTHENTICATION
BILLING
28
CIRCUIT/PACKET TO ATM
66
TO SIGNALING NETWORK
30
34
36
36
32
32
12
12
BASE STATION
RADIO RESOURCE MGMT
CONNECTION CONTROL
BASE STATION
RADIO RESOURCE MGMT
CONNECTION CONTROL
CELLULAR SWITCH
26
IN-BAND SIGNALING
SWITCHING FABRIC CONTROL
24
TO PSTN
VOCODER
SEPARATOR COMBINER
FRAME SELECTOR
22
20
18
10
16
14

FIG. 3

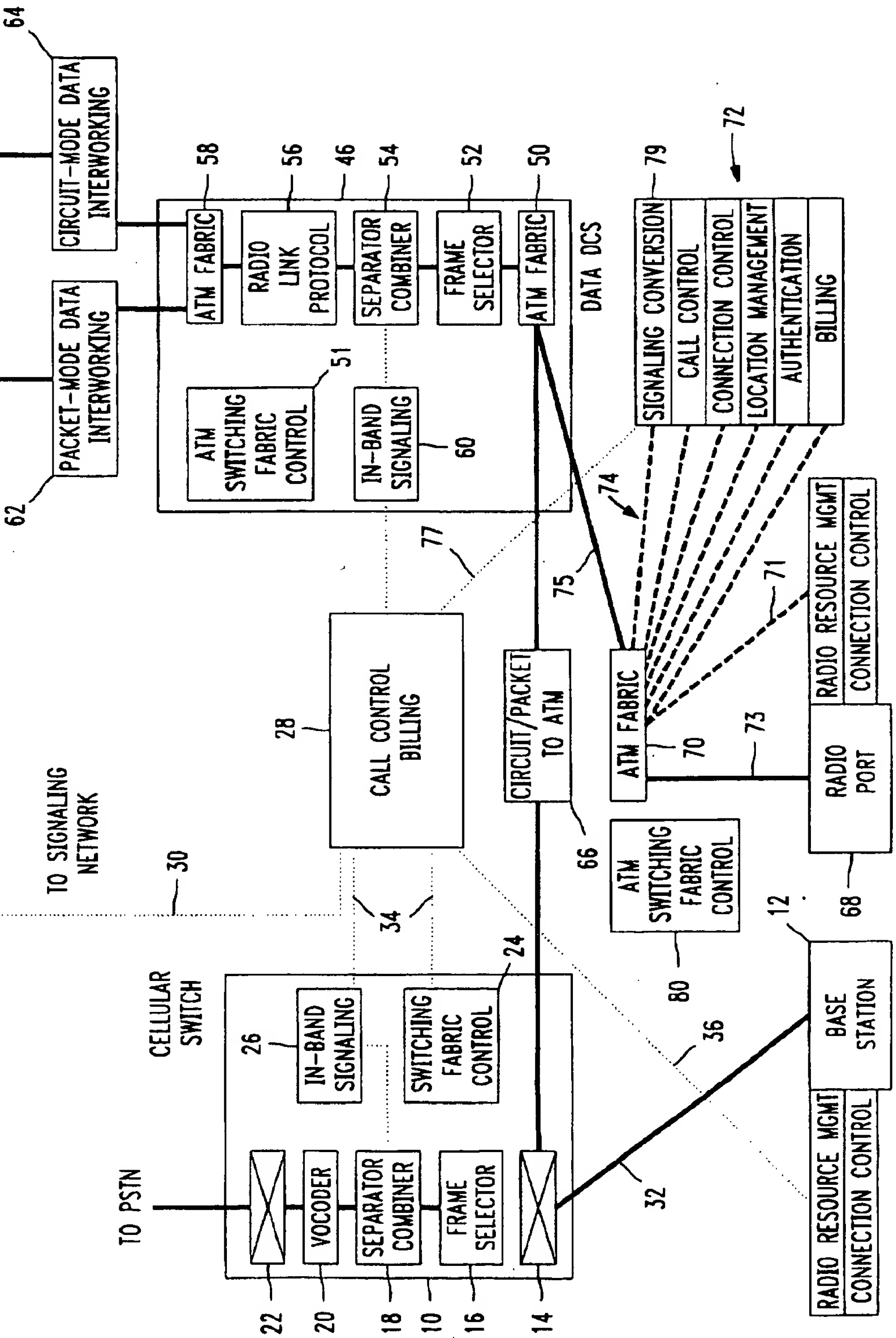

TO PSTN
CIRCUIT-MODE DATA INTERWORKING
64
TO PSPDN
PACKET-MODE DATA INTERWORKING
62
ATM FABRIC
58
RADIO LINK PROTOCOL
56
46
SEPARATOR COMBINER
54
FRAME SELECTOR
52
ATM FABRIC
50
DATA DCS
ATM SWITCHING FABRIC CONTROL
51
IN-BAND SIGNALING
60
SIGNALING CONVERSION
CALL CONTROL
CONNECTION CONTROL
LOCATION MANAGEMENT
AUTHENTICATION
BILLING
79
72
74
77
75
CALL CONTROL BILLING
28
CIRCUIT/PACKET TO ATM
66
ATM FABRIC
70
71
RADIO RESOURCE MGMT
CONNECTION CONTROL
73
RADIO PORT
68
ATM SWITCHING FABRIC CONTROL
80
TO SIGNALING NETWORK
30
34
CELLULAR SWITCH
IN-BAND SIGNALING
26
SWITCHING FABRIC CONTROL
24
TO PSTN
VOCODER
SEPARATOR COMBINER
FRAME SELECTOR
22
20
18
10
16
14
32
36
12
BASE STATION
RADIO RESOURCE MGMT
CONNECTION CONTROL

FIG. 4

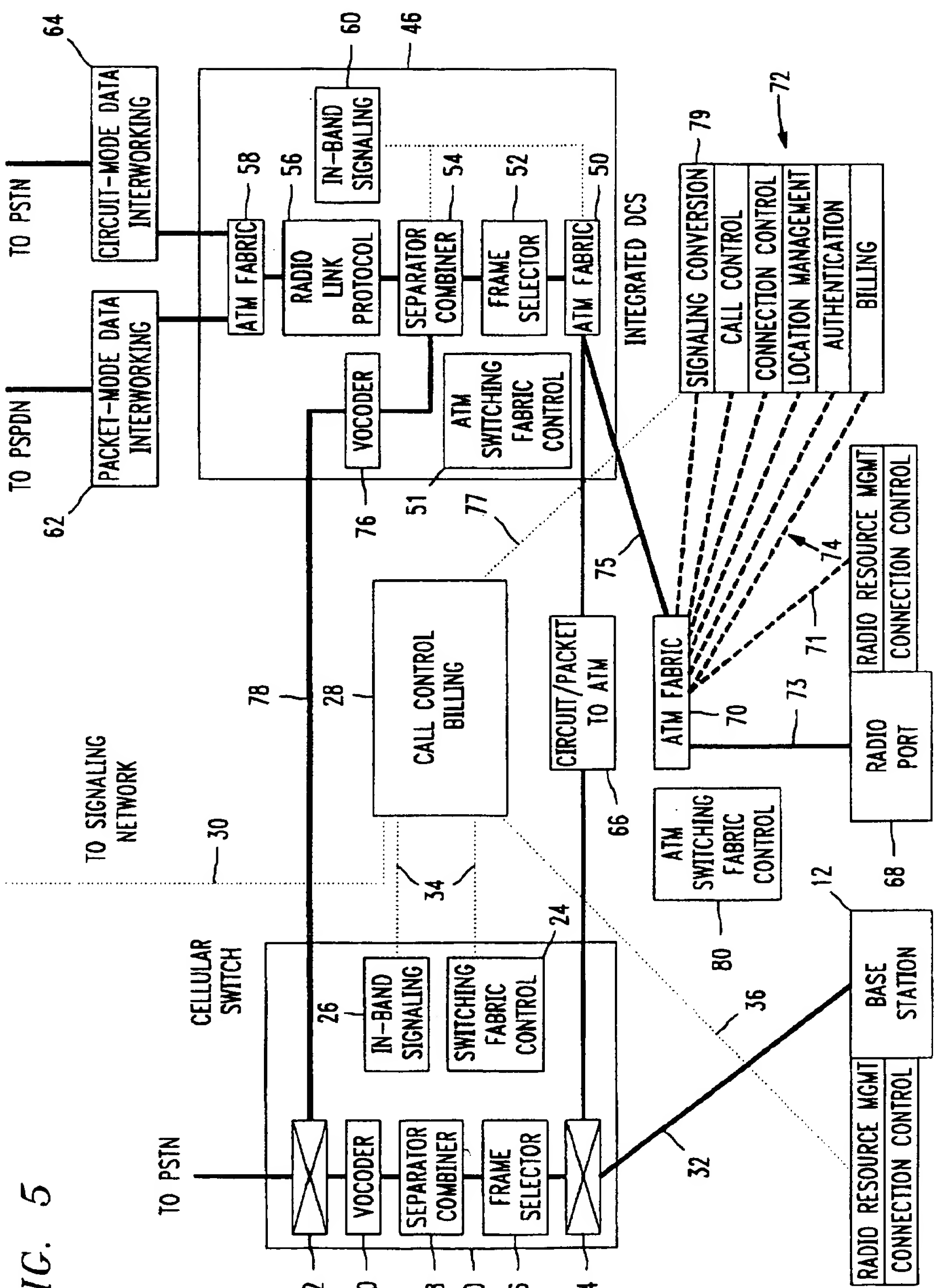

TO PSTN
CIRCUIT-MODE DATA INTERWORKING
TO PSPDN
PACKET-MODE DATA INTERWORKING
ATM FABRIC
RADIO LINK PROTOCOL
IN-BAND SIGNALING
SEPARATOR COMBINER
FRAME SELECTOR
ATM FABRIC
INTEGRATED DCS
VOCODER
ATM SWITCHING FABRIC CONTROL
SIGNALING CONVERSION
CALL CONTROL
CONNECTION CONTROL
LOCATION MANAGEMENT
AUTHENTICATION
BILLING
RADIO RESOURCE MGMT
CONNECTION CONTROL
CALL CONTROL BILLING
CIRCUIT/PACKET TO ATM
ATM FABRIC
RADIO PORT
TO SIGNALING NETWORK
ATM SWITCHING FABRIC CONTROL
CELLULAR SWITCH
IN-BAND SIGNALING
SWITCHING FABRIC CONTROL
BASE STATION
TO PSTN
VOCODER
SEPARATOR COMBINER
FRAME SELECTOR
RADIO RESOURCE MGMT
CONNECTION CONTROL
64
60
46
58
56
54
52
50
79
72
62
76
51
77
75
74
71
73
70
78
28
66
30
34
24
80
12
68
26
36
32
22
20
18
10
16
14

FIG. 5

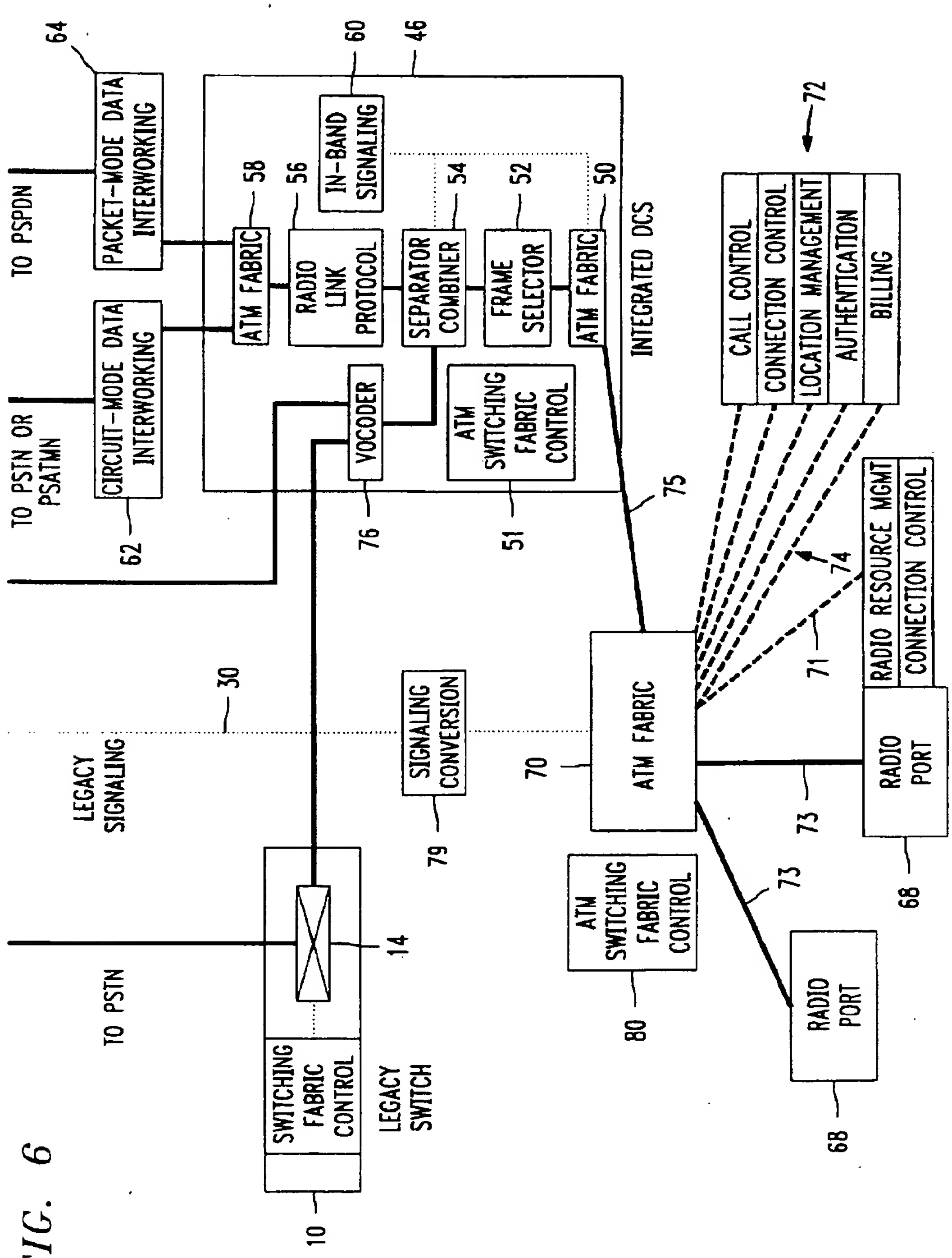

TO PSPDN
PACKET-MODE DATA INTERWORKING
64
TO PSTN OR PSATMN
CIRCUIT-MODE DATA INTERWORKING
62
ATM FABRIC
58
RADIO LINK PROTOCOL
56
IN-BAND SIGNALING
60
46
SEPARATOR COMBINER
54
FRAME SELECTOR
52
ATM FABRIC
50
INTEGRATED DCS
VOCODER
76
ATM SWITCHING FABRIC CONTROL
51
75
CALL CONTROL
CONNECTION CONTROL
LOCATION MANAGEMENT
AUTHENTICATION
BILLING
72
74
71
RADIO RESOURCE MGMT
CONNECTION CONTROL
30
LEGACY SIGNALING
SIGNALING CONVERSION
79
70
ATM FABRIC
73
RADIO PORT
68
ATM SWITCHING FABRIC CONTROL
80
RADIO PORT
68
TO PSTN
14
SWITCHING FABRIC CONTROL
LEGACY SWITCH
10

FIG. 6

CELLULAR SYSTEM ARCHITECTURES SUPPORTING DATA SERVICES

FIELD OF THE INVENTION

The present invention relates to a progression of cellular system architectures that allows voice and data traffic to be gradually migrated from the legacy circuit/packet based digital cellular infrastructure to a target ATM-based cellular infrastructure.

BACKGROUND OF THE INVENTION

Almost all the cellular mobile systems in existence today and those being deployed were designed with voice transport as the primary function. The air interface, the cellular switch, and the wireline infrastructure connecting the base stations to the public switched network have all been optimized for voice transport. This is true for analog (AMPS) systems as well as new standards based digital systems such as TDMA (time-division multiple access) and CDMA (code-division multiple access). TDMA systems are based, for example, on North American Telecommunications Industries Association (TIA) standard IS54/136 or Global System for Mobile Communications (GSM), and CDMA systems are based on for example. TIA IS-95.

In the IS-95 systems, the voice samples are variable bit rate coded and transmitted over an air interface. Circuit or packet based transport is used between base station and cellular switch. At the cellular switch, a frame selector selects the best frame from among those received along multiple paths used during soft handoffs (when the connection is not in soft handoff mode, only one path exists between a mobile and the cellular switch, and the frame selector function is redundant). The frame selector forwards the selected frame to a vocoder which converts the variable bit rate coded voice to fixed rate PCM coded voice to be carried over the public switched telephone network (PSTN). PSTN voice circuits carry PCM coded voice at, for example, 64 Kbps (DS0). Corresponding inverse functions are performed in the opposite direction, PSTN-to-mobile.

The air interface also carries signaling information in-band in the traffic channel and out-of-band over a control channel. In-band signaling information is separated from the voice packets at the frame selector. Out-of-band signaling information is carried over separate circuit or packet links between the base station and the cellular switch or the cellular call control (a separate processor that processes and acts on the signaling messages). Besides the in-band signaling used for radio channel control and other real-time functions, and the out-of-band signaling used for call establishment, registration, etc., cellular mobile systems also perform call processing, billing, authentication, mobility management, handoff management, routing and other higher layer functions (e.g., network management).

Recently, data services have generated great interest and standards activities for cellular systems (e.g., TDMAIS-136, GSM, CDMA IS-99). In CDMA systems, data and voice may be integrated over the radio channel (air interface) with data being a secondary service sharing bandwidth with voice as the primary. Variable bit rate coded voice samples allow idle space in the physical layer slots (e.g., IS-95 physical bursts 20 ms long) and data can use this idle space as and when available. Besides this integrated mode, a data-only service is available in CDMA systems. Here, data is the primary traffic with only in-band signaling as secondary traffic.

Many functions in the cellular infrastructure (e.g., billing, authentication, routing, network management) are similar for both voice and data services and can thus be provided efficiently using common platforms. On the other hand, data services represent some fundamental departures from the traditional infrastructure designed for voice. For example, the vocoder function, typically tightly coupled with the frame selector, is not needed for data. Also, data may be carried over either the circuit-switched PSTN or over a public switched packet data network (PSPDN).

Moreover, since the air interface environment is hostile and results in larger error rates than from wireline infrastructure, link layer recovery is performed between the mobile and the interworking function. This allows the cellular infrastructure to appear like a wireline link in end-to-end connections. In CDMA systems, the link layer recovery is performed using TCP/IP protocol. Additionally, a radio link protocol (RLP) is used between the mobile and the cellular switch. By retransmitting only physical layer data frames in error RLP provides a high bandwidth efficiency. These recovery protocols, however, cannot be used for highly interactive voice services because of the delay introduced (e.g., due to retransmissions).

Commonality of many functions, significant differences in key aspects of transport, and extensive embedded infrastructure optimized for voice create challenges when data needs to be carried over the same air interface as voice. The challenges relate to defining a long term target infrastructure for carrying CDMA data and voice, a short term solution leveraging the existing infrastructure, and defining intermediate system architectures for providing a smooth and cost effective migration from the current architecture to the long term target.

FIG. 1 shows a schematic of the current network architecture used for digital cellular. In particular, this architecture is used for CDMA, but the TDMA architecture is essentially similar. Base stations 12 are connected to a cellular switch 10 via circuit or packet links 32. Terminal devices (not shown) such as telephone handsets, personal communicators and other mobile units communicate with the base stations 12 over an air interface.

The cellular switch 10 (e.g., AT&T's 5ESS) has a standard digital switching fabric 14, 22 under control of processor 24. As is well understood in the art, logically separate switching functions 14, 22 are typically implemented on common hardware. The cellular switch 10 also incorporates the additional functions of frame selector 16, separator and combiner 18, and vocoder 20. The vocoder function 20 is required for transcoding of standard 64 kbps PCM voice, widely used in today's PSTN, to variable bit rate LPC (linear predictive coded) or other packetized voice transmitted over the digital cellular radio links 32. The frame selector 16 is CDMA specific. The frame selector 16 is used to select the best packet of the ones received from multiple legs 32 during soft handoff, and also to multicast a packet to multiple base stations 12 during soft handoff. The separator and combiner functions 18 are needed to form the air interface packet by merging the coded voice octets with the signaling. In-band signaling control and processing (from/to the mobile) is performed by the in-band signaling function 26.

In CDMA, air interface packet formats are designed to accommodate primary and secondary traffic, as well as signaling. In initial deployments, voice will be primary traffic and will share the bandwidth with signaling. No secondary traffic will be carried and so this system, as depicted in FIG. 1, will be voice-only.

Cellular control functions include call control, location management, authentication, and billing. As in the analog cellular networks of today, these cellular control functions are distributed between the base stations and the MTSO (Mobile Telephone Switching Office) or MSC (Mobile Switching Center). For example, these functions could be resident in the cellular switch 10 or, as shown in FIG. 1, resident in a separate cellular call control processor complex 28. The call control processor complex 28 communicates with the call controllers in the PSTN and other cellular networks over signaling links 30 which may be the SS7 network or as specified in TIA IS-41. Signaling links 34 to the cellular switch 10 and signalling links 36 to the base stations (implementing for example X.25) are used to establish connections for calls and in general for system control. The signalling links typically use packet protocols over dedicated circuits, whereas the user data links 32 may be circuit-switched or packet-switched. In the current AT&T architecture, for example, the links 32 are called "packet pipes" which carry a version of Frame Relay protocol. See U.S. Pat. No. 5,195,090 entitled "Wireless Access Telephone-to-Telephone Network Interface Architecture". This protocol terminates on packet handlers (not Shown) in the cellular switch 10, which extract the frames and send them to the frame selector 16 over a packet bus.

FIG. 2 shows how data services have been introduced into the voice-only architecture of FIG. 1. Using a vocoder by-pass, the data bytes extracted from the integrated IS-95 slots are sent to a radio link protocol (RLP) 42. The RLP software performs link layer recovery. A frame relay packet handler (not shown) connects the RLP 42 to the interworking functions (IWF) 38, 40. The IWFs 38, 40 implement TCP and manage connectivity to the PSTN and PSPDN. Thus a circuit-mode data call consists of two links, a cellular link between the mobile terminal and the circuit-mode IWF, and a land-line link from the land-line modem over the PSTN, to a modem in the modem pool (circuit-mode IWF). The circuit-mode IWF is just a modem pool which communicates with the call control for circuit-mode data call establishment and tear-down. In addition, the packet-mode IWF 38 handles routing, billing, authentication, and mobility management. For circuit data all these functions are provided by the cellular call control processor 28. The IWFs 38, 40 communicate with the call control processor 28 by, for example, SS7 signaling links 44.

Since CDMA air interface packet formats are defined to carry primary and secondary traffic and signaling within the same packet, the vocoder 20 and the RLP 42 must both reside with the separator and combiner 18. The interfaces (not shown) with the IWFs 38, 40 for circuit-mode and packet-mode data services may also reside within the cellular switch 10.

While providing a quick solution for the introduction of data services, this approach suffers from many problems including nontrivial effort in effecting vocoder bypass in the legacy hardware, mix of circuit and packet transport, and inflexible hardware and software technology. Collectively, these problems add significantly to the time-to-market for new features, to the capital cost for growth, and to the operational complexity and cost, and limit the flexibility with which future services (e.g., higher speed data, multimedia, etc.) can be added.

SUMMARY OF THE INVENTION

In the present invention, data services, ATM-based transport and switching, and object-oriented modular programming on industry standard hardware platforms are gradually introduced into the legacy digital cellular architecture while reusing much of the existing voice infrastructure. Such introduction preferably occurs in four stages, though it is recognized that different service providers might progress through the four stages at different rates or even bypass certain stages entirely.

The first stage cellular communication system architecture includes: a plurality of base stations that communicate over an air interface with a plurality of terminal devices; a cellular switch having circuit-switching fabric and vocoders, where said base stations are connected to said circuit-switching fabric by first communications links, and where said circuit-switching fabric is also connected to a public switched telephone network (PSTN); a cellular call control processor, associated with said cellular switch, that handles a voice call routed through said cellular switch; a data DCS having ATM fabric and radio link protocol processors, where said circuit-switching fabric is connected to said ATM fabric by a second communications link via a converter that converts between the transmission format of said first communications links and ATM; a data call control processor, associated with said data DCS, that handles a data call routed through said data DCS and said cellular switch; and a network interworking module that interfaces said data DCS to a communications network.

Voice calls are set-up by said cellular call control processor so that a voice communication path is established from one of said terminal devices to said PSTN. A voice communication path includes said air interface, one or more of said base stations and first communications links, said circuit-switching fabric, and one of said vocoders.

Data calls are set-up by said cellular call control processor and said data call control processor so that a data communication path is established from one of said terminal devices to said communications network. A data communication path includes said air interface and one or more of said base stations and first communications links, said circuit-switching fabric, said converter, said ATM fabric, one of said radio link protocol processors, and said network interworking module.

The second stage cellular communication system architecture includes: a plurality of base stations and radio ports that communicate over an air interface with a plurality of terminal devices, where said radio ports have ATM interfaces; a cellular switch having circuit-switching fabric and vocoders, where said base stations are connected to said circuit-switching fabric by first communications links, and where said circuit-switching fabric is also connected to a public switched telephone network (PSTN); a cellular call control processor, associated with said cellular switch, that handles a voice call routed through said cellular switch; a DCS having ATM fabric and radio link protocol processors, where said circuit switching fabric is connected to said ATM fabric by a second communications link via a converter that converts between the transmission format of said first communications links and ATM, and where said ATM fabric is connected to said radio ports by ATM virtual links; one or more standard hardware platforms implementing ATM transport that perform a plurality of call control functions including the handling of data calls from/to said base stations and radio ports; and a network interworking module that interfaces said DCS to a communications network.

Voice calls are set-up by said cellular call control processor so that a voice communication path is established from one of said terminal devices to Said PSTN. A voice com-

munication path includes said air interface, one or more of said base stations and first communications links, said circuit-switching fabric, and one of said vocoders.

Data calls are set-up by said plurality of functions implemented on said standard hardware platforms that are interfaced to a signaling network by said cellular call control processor, so that a data communication path is established from one of said terminal devices to said communications network.

A data communication path involving a base station includes said air interface and one or more of said base stations and first communications links, said circuit-switching fabric, said converter, said ATM fabric, one of said radio link protocol processors, and said network interworking module. On the other hand, a data communication path involving a radio port includes said air interface and one or more of said radio ports and ATM virtual links, said ATM fabric, one of said radio link protocol processors, and said network interworking module.

In a third stage architecture, vocoders are included in the DCS, and a voice communication path from a terminal device to the PSTN through the DCS includes the air interface and one or more of the radio ports and ATM virtual links, the ATM fabric, and one of the vocoders, whereby the DCS can process both voice and data calls.

The fourth stage cellular communication system architecture includes: a plurality of radio ports that communicate over an air interface with a plurality of terminal devices, where said radio ports have ATM interfaces; a cellular switch having circuit-switching fabric, where said cellular switch is connected to a public switched telephone network (PSTN); a DCS having ATM fabric, radio link protocol processors, and vocoders, where said vocoders are connected to said PSTN, and where said ATM fabric is connected-to said radio ports by ATM virtual links; one or more standard hardware platforms implementing ATM transport that perform a plurality of call control functions including the handling of voice and data calls from/to said radio ports; and a network interworking module that interfaces said DCS to a communications network.

Voice calls are set-up by said plurality of functions implemented on said standard hardware platforms, so that a voice communication path is established from said terminal device to said PSTN, including said air interface and one or more of said radio ports and ATM virtual links, said ATM fabric, and one of said vocoders. Data calls are set-up by said plurality of functions implemented on said standard hardware platforms, so that a data communication path is established from said terminal device to said communications network, including said air interface and one or more of said radio ports and ATM virtual links, said ATM fabric, one of said radio protocol processors, and said network interworking module.

DESCRIPTION OF THE DRAWINGS

The invention will be described in greater detail below with reference to the attached drawings, of which:

FIG. 1 shows the current digital cellular architecture for a CDMA voice-only system.

FIG. 2 shows the current digital cellular architecture supporting a data service.

FIG. 3 shows the stage one digital cellular architecture of the present invention which introduces an ATM-based data DCS and distributed call processing.

FIG. 4 shows the stage two digital cellular architecture of the present invention which introduces ATM-based radio ports-and migrates control functions.

FIG. 5 shows the stage three digital cellular architecture of the present invention which introduces vocoders in the DCS.

FIG. 6 shows the stage four digital cellular architecture of the present invention which is the ATM-based target architecture.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention introduces four cellular system architectures which correspond to four stages of growth for the current digital cellular system architecture of FIG. 1. The first stage introduces data services by way of a separate data DCS (digital cellular switch) that has an Asynchronous Transfer Mode (ATM) switching fabric. The call control processing functions are distributed by providing a separate data call control processor for data calls. The second stage introduces ATM at the radio port and moves most of the call control functions on to standard hardware platforms connected by ATM transport and switching. The third stage adds vocoders to the DCS (now referred to as an "integrated" DCS) which allows the radio ports to handle voice calls. The fourth stage (i.e., the target architecture) removes cellular specific functions from the legacy cellular switch, eliminates altogether the legacy cellular call control processor, and utilizes minimal functionality radio ports. This target architecture is described in a commonly assigned, co-pending U.S. patent application Ser. No. 08/395,546 filed Feb. 28, 1995 entitled "Handoff Management For Cellular Telephony" the disclosure of which is incorporated by reference herein.

Referring to FIG. 3 there is shown the stage one cellular architecture. The underlying assumption for this architecture is that voice and data calls are kept separate. No joint voice-data calls would be carried during this stage of system development. The handling of voice calls by base stations 12, cellular switch 10, and call control processor 28 is the same as in the current architecture. Data calls however are handled by the introduction of an ATM-based adjunct called a data DCS 46 and by a separate data call control processor 48.

The data DCS 46 has a structure similar to the data path shown in FIG. 2, though the DCS 46 switching fabric 50, 58 is ATM-based and controlled by ATM switching fabric control 51. The data DCS 46 has a data path which includes a frame selector 52, a separator/combiner 54, and a RLP 56. In-band signaling control is provided by processor 60. A packet-mode IWF 62 provides data access to the PSPDN and a circuit-mode IWF 64 provides data access to the PSTN. These IWFs have the same functionality as IWFs 38 and 40 in FIG. 2, except that the transport between IWFs and DCS is ATM.

The existing call control processor 28 still provides authentication, paging and location management functions for the data calls. When a data call arrives at call control processor 28, it is forwarded to the data call control processor 48 for further handling. The data call control functions include connection control, billing, and signaling conversion (e.g., between SS7 and ATM standards such as Q.2931).

The switching fabric 14 of cellular switch 10, directs data calls to the data DCS 46 by way of converter 66. DSO cross-connects for data calls are semi-permanently assigned to a number of output ports of switch 14 for transport to the data DCS 46. Converter 66 converts either the packets from packet links 32 or from circuit links 32 of the cellular network to ATM and vice-versa.

The data call control 48, the IWFs 62, 64, the RLP 56 and other data DCS 46 functions are all introduced on inexpensive modern hardware platforms (e.g., PCs, workstations) using standard networking (e.g., ATM transport and switching, TCP/IP). This ensures flexibility for the future, easy growth paths and technology expansion. Therefore, as described, the stage one architecture utilizes DS0 cross-connects to provide a data solution on platforms outside the cellular switch. The cellular switch itself can provide DS0 cross-connect facilities, however a cheaper alternative (and used by some cellular providers for modem pool connectivity) is to install an adjunct cross-connect platform (DACS).

An example of voice and data call setups for the stage one architecture is as follows:

Voice Call Setup

1. Call arrivals from the land side arrive at the call control processor 28 over SS7 links 30. After looking up location information, call control pages the mobile over all base stations 12 in a location area. Call arrivals from the mobile arrive from the base station via signaling links 36.
2. Call Control authenticates the mobile (using the origination or pages response message or extended authentication sequence).
3. Call control assigns a circuit or packet link other for the call and informs switching fabric control 24 at the cellular switch 10, and the connection control function at the base station 12. The connection is established by the switch and the base station.
4. The switch completes the connection to the frame selector 16 and on to the PSTN.
5. The base station establishes the air interface link with the mobile.

Data Call Setup: Mobile Origination

1. Mobile originates call with a data service option.
2. Call Control 28 authenticates the mobile (using the origination message or other extended authentication sequence).
3. Call Control assigns a circuit or packet link 32 between base station and the ATM conversion device 66, on a circuit cross-connected through the Switching fabric 14.
4. Call Control requests data call controller 48 to establish the remaining segment to IWF. Data call controller assigns a frame selector/radio link protocol and other processing devices to the call, and sets up a virtual circuit link from ATM conversion device 66 through ATM switching fabric 50 to the assigned frame selector. Data call controller also sets up the ATM virtual circuit link between the radio link protocol/frame selector and the appropriate IWF.
5. In the case of a circuit-mode call, the land-line dial string is received from the mobile and provided by the call control through the data call control Go the circuit-mode IWF. The data call controller also assigns a modem from the circuit mode IWF (modem pool) which dials out the number over the PSTN. For the latter dial-up purpose, the cellular switch 10 may be used as a generic PSTN switch.

Data Call setup: Land Origination Circuit-Mode

1a. A special PSTN number is assigned to the circuit-mode IWF (modem pool) 64. When a call request arrives over the SS7 link 30 for the special modem pool number, call control 28 requests data call controller 48 to assign a modem from the circuit IWF 64. Call control assigns a PSTN circuit through the switching fabric 22 (or alternatively, through another switch in the PSTN) to the assigned modem.

1b. Once the modem connection is established, the land-line modem provides the mobile called party number to the modem at the modem pool. This number is provided to the data call controller. The data call controller requests call control to locate and page the mobile. After looking up mobile location information, call control pages mobile with circuit data service option.

2. Call control authenticates the mobile (using the page response message or other extended authentication sequence).
3. On page response, call control assigns a circuit or packet link between base station and ATM conversion device 66.
4. Call Control requests data call controller 48 to establish the remaining segment to the circuit IWF. Data call controller assigns a frame selector/radio link protocol and other processing devices to the call, and sets up a virtual circuit link from ATM conversion device 66 through ATM switching fabric 50 to the assigned frame selector. Data call controller also sets up the ATM virtual circuit link between the radio link protocol/frame selector and the circuit IWF.

Data Call Setup: Land Origination Packet-Mode

1. Packet data arrives over PSPDN for a registered mobile. (If packet data arrives for a nonregistered mobile, it is discarded). The packet IWF looks up registration information and maps the packet data routing address to the mobile called party number. This number is provided to the data call controller, which requests call control to locate and page the mobile. After looking up mobile location information, call control 28 pages mobile with packet data service option.
2. Call control authenticates the mobile (using the page response message or other extended authentication sequence).
3. On page response, call control assigns a circuit or packet link between base station and ATM conversion device 66.
4. Call Control requests data call controller 48 to establish the remaining segment to the packet IWF. Data call controller assigns a frame selector/radio link protocol and other processing devices to the call, and sets up a virtual circuit link from ATM conversion device 66 through ATM switching fabric 50 to the assigned frame selector. Data call controller also sets up the ATM virtual circuit link between the radio link protocol/frame selector and the packet IWF.

Prior to paging, the call control 28 must look up location information. In the stage one architecture this location information is stored in the call control processor 28. In the stage two architecture (described subsequently) this database is moved over to the new control complex 72. In addition, call control 28 in the stage one architecture authenticates the mobile prior to establishing base station to switch connections. In the stage two architecture this procedure is also handled in the new control complex 72.

The stage two architecture is shown in FIG. 4. While continuing to use packet or circuit links 32 to existing base stations, at this stage new radio ports 68 with ATM interfaces are introduced. These radio ports 68 can connect into the previously introduced ATM-based data DCS network. Such connection may be directly to the data DCS 46 or via one or more intermediate ATM switches 70. Data calls over non-ATM base stations are still handled as in stage one through the data DCS via converter 66.

Radio ports may provide the functionality of conventional base stations, such as radio resource management and connection control However, at later stages of the system architecture, many of these functions can be moved out of the radio port and into the MSC or elsewhere in the ATM network, thereby having the radio port serve the minimal functionality of terminating the protocol on the air interface. Thus allowing, for example, street post mounted low-cost radio ports where maintenance intensive functions have been moved to the network backbone.

In the stage two architecture, the radio ports 68 can only handle data calls and not voice-only or joint voice-data calls. User data traffic is carried between radio port 68 and ATM switch 70 via ATM virtual links 73, and signaling information is carried via virtual circuit link 71 (over the same facility). User data and signaling ATM virtual links 75 couple data DCS 46 to ATM switch 70 which is controlled by, for example, ATM switching fabric control 80. The connection 77 between the legacy call control 28 and the signaling conversion function 79 may, for example, be by TCP/IP networking. During this stage of mixed ATM and packet (frame relay) or circuit networking, it is necessary to provide packet/circuit to ATM conversion, as the mobile moves between ATM interfaced radio ports 68 and packet or circuit interfaced base stations 12.

As shown in FIG. 4, most of the call control functions are now moved out of the legacy call control processor 28 on to standard hardware platforms 72 (e.g., PCs or workstations) using standard networking 74 (e.g., ATM transport and switching, and TCP/IP). Existing voice call control, interfaces to the SS7 network, and perhaps billing are still used in call control processor 28 as before, while all other functions have been migrated to the target architecture. These migrated functions are designed using standard object and message paradigms so that clear interfaces are defined between these objects enabling easy distribution over multiple hardware platforms 72. The ATM transport also enables efficient networking for user data and signaling through logical links 74 for all control functions over multiple hardware platforms 72. Thus control functions from the radio ports, for example, Radio Resource Management may be moved to the new call control 72.

The architecture for the data DCS 46 is well suited for easy growth. Vocoders, the radio link protocol 56, interfaces to the interworking functions 62 and 64, and other cellular specific functions (e.g., frame selection 52 and separator/Combiner 54) can all be implemented on standard hardware platforms and grown to run over multiple platforms with ATM connectivity. Using industry standard platforms also permits the systems to ride the technology curve for growth. This highlights the differences between the cellular switch 10 and the data DCS 46. The cellular switch 10 is a proprietary hardware platform with expensive TSI (time slot interchange) based circuit switching, frame based pocket switched proprietary buses, and ATM interfaces with all cellular specific functions crowded into the switch hardware. In contrast, the data DCS 46 consists of an easily growable number of industry standard hardware platforms (e.g., PCs, workstations), standard networking and software designs, industry standard buses, and underlying ATM switching. That is, the data DCS 46 is a loose collection of hardware tied together with ATM, either located in one place or distributed in multiple locations. The box around the data DCS 46 and the joint placement of the new call control functions 72 in FIG. 4 are thus only descriptive in a logical sense, and do not imply physical constraints.

In the stage three architecture, shown in FIG. 5, vocoders 76 are provided in the DCS 46 which may now be referred to as an integrated DCS 46 because both voice and data calls can be processed by the DCS. These vocoders 76 access the PSTN via communications link 78 and cellular switch 10. It would also be possible to access the PSTN directly by providing, for example, a T1 interface at DCS 46. In-band signaling is separated from the user data and voice at the separator/combiner 54 and sent to the new call control 72 over ATM virtual links (e.g., via ATM switching fabric 50 and ATM switch 70).

It may also be noted that the stage one architecture could be migrated directly to the stage three architecture without the-intermediate vocoder-less DCS 46 of FIG. 4.

After all cellular base stations 12 have been converted to ATM connectivity, it becomes unnecessary to provide cellular specific functions like frame selector, separator and combiner, vocoder in the cellular switch 10. Then, as shown in FIG. 6, they can be removed so that the-cellular switch 10 is reduced to a basic circuit switch, which may still be used to provide connectivity to the circuit-switched PSTN. The vocoder 76 may also directly access the PSTN or a public switched ATM network (PSATMN).

We note that the slower rate of technology penetration in the mature public network implies that the legacy switch 10 would be needed for several years after the introduction of the stage four architecture shown in FIG. 6, even after all cellular base stations 12 have been converted to ATM connectivity.

The architecture of FIG. 6 permits easy migration to two possible evolution paths for the public network. If the public network remains circuit-switched, the expensive legacy switch 10 can be expanded in fabric size but the expensive functions implemented with outdated technology are migrated out to inexpensive industry standard platforms. With heavy growth promised in cellular, this is an attractive path where existing switches can still be used while newer switches could be less expensive. On the other hand, if the public network migrates to ATM, then the vocoder function could be moved further to the egress from the public network (far-end), providing efficient packet transport of cellular voice over the PS-ATM network.

The present invention provides a tight coupling of the RLP, vocoder and in-band signalling handler on the integrated DCS which permits flexible and efficient multiplexing of voice, data, and signaling through adaptive priorities (e.g., high priority signaling over user data, or retransmitted data over voice). Moreover, the ATM-based system architecture permits an easy migration to higher data rates planned for the future.

Although the invention has been described in detail with particular reference to a preferred CDMA embodiment thereof, it should be understood that the invention may also be practiced in a TDMA cellular system.

Differences between CDMA and TDMA implementation may be considered by comparing the operation of each for the stage four architecture. First consider a CDMA communication from mobile to public network in the case of a voice-only call, a data-only call, and then a joint voice-data call.

In a CDMA voice-only call, frame selector 52 selects the best incoming frame and separator 54 separates in-band signaling for routing to in-band signaling block 60. The primary voice is routed to vocoder 76. It may be noted that in-band signaling block 60 indicates that the preferred consolidation point for in-band signaling is at the integrated DCS 46, though it is possible to separate in-band signaling at the radio ports/base stations. For a data-only call, frame selector 52 selects the best frame, separator 54 separates

in-band signaling, and the primary data is routed to RLP 56. For a joint voice-data call, frame selector 52 selects the best frame, and separator 54 separates primary voice and secondary data for routing to vocoder 76 and RLP 56, respectively (instead of carrying voice and data, the packet could carry voice and signaling, in which case the separator would route signaling to block 60).

In the TDMA case, there is no frame selector 52 or separator/combiner 54, although a similar control function of extracting/inserting in-band signaling information is performed. The preferred consolidation point for in-band signaling in a TDMA system is at the base station/radio port, in which case circuit or packet links 32 may be used to carry some of the control data between base station 12 and cellular switch 10 or a virtual link may be used between radio port 68 and DCS-46. Voice and data in the TDMA-based DCS are routed through ATM fabric 50 to either the vocoder 76 or RLP 56, respectively, in accordance with each cell being marked with the appropriate vertical circuit identifier (VCI).

While the invention has been described in conjunction with preferred embodiments thereof, various modifications and substitutions can be made thereto without departing from the spirit and scope of the present invention.

We claim:

1. A method for introducing data and integrated voice/data services to a legacy digital cellular network having a plurality of base stations that communicate over an air interface with a plurality of terminal devices, a cellular switch having circuit-switching fabric in communication with a public switched telephone network (PSTN) and said base stations, where said cellular switch includes vocoders for voice calls, and a cellular call control processor that handles voice calls routed through said cellular switch, comprising the steps of:

deploying a data digital cellular switch (DCS) having ATM switching fabric and a radio link protocol processor, and deploying an associated data call control processor for handling data calls routed through said data DCS and said cellular switch;

deploying a plurality of radio ports having ATM interfaces, and deploying one or more standard hardware platforms implementing ATM transport that perform a plurality of call control functions including the handling of data calls from/to said base stations and radio ports, where data calls involving said radio ports are not routed through said cellular switch; and

deploying vocoders in said data DCS for processing voice calls involving said radio ports.

2. A cellular communication system comprising:

a plurality of base stations that communicate over an air interface with a plurality of terminal devices;

a cellular switch having circuit-switching fabric and vocoders, where said base stations are connected to said circuit-switching fabric by first communications links, and where said circuit-switching fabric is also connected to a public switched telephone network (PSTN);

a cellular call control processor, associated with said cellular switch, that handles a voice call routed through said cellular switch;

a data digital cellular switch (DCS) having ATM fabric and radio link protocol processors, where said circuit-switching fabric is connected to said-ATM fabric by a second communications link via a converter that converts between the transmission format of said first communications links and ATM;

a data call control processor, associated with said data DCS, that handles a data call routed through said data DCS and said cellular switch;

a network interworking module that interfaces said data DCS to a communications network;

wherein a voice call is set-up by said cellular call control processor so that a voice communication path is established from one of said terminal devices to said PSTN, said voice communication path including said air interface, one or more of said base stations and first communications links, said circuit-switching fabric, and one of said vocoders;

wherein a data call is set-up by said cellular call control processor and said data call control processor so that a data communication path is established from one of said terminal devices to said communications network, said data communication path including said air interface and one or more of said base stations and first communications links, said circuit-switching fabric, said converter, said ATM fabric, one of said radio link protocol processors, and said network interworking module.

3. The system of claim 2, wherein said cellular communication system implements CDMA, and data paths in said cellular switch and said data DCS include a frame selector and a separator/combiner.

4. The system of claim 2, wherein said cellular communication system implements TDMA.

5. The system of claim 2, wherein said first communications links may be circuit or packet links, and said converter converts between circuit or packet formats and ATM.

6. The system of claim 2, wherein said network interworking module comprises a circuit-mode data interworking module that interfaces said data DCS to said PSTN, and where said interworking module includes a pool of modems.

7. The system of claim 6, wherein said network interworking module further comprises a packet-mode data interworking module that interfaces said data DCS to a public switched packet data network (PSPDN).

8. The system of claim 2, wherein said data call control processor, said network interworking module, and functions of said data DCS including said radio link protocol processors are implemented on standard hardware platforms interconnected by ATM transport and switching.

9. The system of claim 8, wherein said standard hardware platforms include workstations or personal computers.

10. A cellular communication system comprising:

a plurality of base stations and radio ports that communicate over an air interface with a plurality of terminal devices, where said radio ports have ATM interfaces;

a cellular switch having circuit-switching fabric and vocoders, where said base stations are connected to said circuit-switching fabric by first communications links, and where said circuit-switching fabric is also connected to a public switched telephone network (PSTN);

a cellular call control processor, associated with said cellular switch, that handles a voice call routed through said cellular switch;

a digital cellular switch (DCS) having ATM fabric and radio link protocol processors, where said circuit switching fabric is connected to said ATM fabric by a second communications link via a converter that converts between the transmission format of said first communications links and ATM, and where said ATM fabric is connected to said radio ports by ATM virtual links;

one or more standard hardware platforms implementing ATM transport that perform a plurality of call control functions including the handling of data calls from/to said base stations and radio ports;

a network interworking module that interfaces said DCS to a communications network;

wherein a voice call is set-up by said cellular call control processor so that a voice communication path is established from one of said terminal devices to said PSTN, said voice communication path including said air interface, one or more of said base stations and first communications links, said circuit-switching fabric, and one of said vocoders;

wherein a data call is set-up by said plurality of functions implemented on said standard hardware platforms that are interfaced to a signaling network by said cellular call control processor, so that a data communication path is established from one of said terminal devices to said communications network;

wherein said data communication path involving a base station includes said air interface and one or more of said base stations and first communications links, said circuit-switching fabric, said converter, said ATM fabric, one of said radio link protocol processors, and said network interworking module;

and wherein said data communication path involving a radio port includes said air interface and one or more of said radio ports and ATM virtual links, said ATM fabric, one of said radio link protocol processors, and said network interworking module.

11. The system of claim 10, wherein said cellular communication system implements CDMA, and data paths in said cellular switch and said DCS include a frame selector and a separator/combiner.

12. The system of claim 10, wherein said cellular communication system implements TDMA.

13. The system of claim 10, wherein said first communications links may be circuit or packet links and said converter converts between circuit or packet formats and ATM.

14. The system of claim 10, wherein said network interworking module comprises a circuit-mode data interworking module that interfaces said DCS to said PSTN, and where said interworking module includes a pool of modems.

15. The system of claim 14, wherein said networking interworking module further comprises a packet-mode data interworking module that interfaces said DCS to a public switched packet data network (PSPDN).

16. The system of claim 10, wherein said one or more standard hardware platforms include workstations or personal computers.

17. The system of claim 16, wherein the functions of said DCS including said radio link protocol processors are also implemented on standard hardware platforms interconnected by ATM.

18. The system of claim 10, wherein ATM virtual links from said radio ports and said one or more standard hardware platforms performing call control functions, are routed to said DCS via one or more ATM switches.

19. The system of claim 10, wherein said signaling network implements SS7.

20. The system of claim 10, wherein vocoders are included in said DCS, and a voice communication path from a terminal device to said PSTN through said DCS includes said air interface and one or more of said radio ports and ATM virtual links, said ATM fabric, and one of said vocoders, whereby the DCS can process both voice and data calls.

21. The system of claim 20, wherein said voice communication path to said PSTN is by way of said circuit-switching fabric.

22. A cellular communication system comprising:

a plurality of radio ports that communicate over an air interface with a plurality of terminal devices, where said radio ports have ATM interfaces;

a cellular switch having circuit-switching fabric, where said cellular switch is connected to a public switched telephone network (PSTN);

a digital cellular switch (DCS) having ATM fabric, radio link protocol processors, and vocoders, where said vocoders are connected to said PSTN, and where said ATM fabric is connected to said radio ports by ATM virtual links;

one or more standard hardware platforms implementing ATM transport that perform a plurality of call control functions including the handling of voice and data calls from/to said radio ports;

a network interworking module that interfaces said DCS to a communications network;

wherein a voice call is set-up by said plurality of functions implemented on said standard hardware platforms, so that a voice communication path is established from said terminal device to said PSTN, including said air interface and one or more said radio ports and ATM virtual links, said ATM fabric, and one of said vocoders;

and wherein a data call is set-up by said plurality of functions implemented on said standard hardware platforms, so that a data communication path is established from said terminal device to said communications network, including said air interface and one or more of said radio ports and ATM virtual links, said ATM fabric, one of said radio protocol processors, and said network interworking module.

23. The system of claim 22, wherein said cellular communication system implements CDMA, and data paths in said DCS include a frame selector and a separator/combiner.

24. The system of claim 22, wherein said cellular communication system implements TDMA.

25. The system of claim 22, wherein said network interworking module comprises a circuit-mode data interworking module that interfaces said DCS to said PSTN or a public switched ATM network (PSATMN), and where said interworking module includes a pool of modems.

26. The system of claim 25, wherein said network interworking module further comprises a packet-mode data interworking module that interfaces said DCS to a public switched packet data network (PSPDN).

27. The system of claim 22, wherein said one or more standard hardware platforms include workstations or personal computers.

28. The system of claim 27, wherein the functions of said DCS including said radio link protocol processors are also implemented on standard hardware platforms interconnected by ATM.

29. The system of claim 22, wherein ATM virtual links from said radio ports and said one or more standard hardware platforms performing call control functions, are routed to said DCS via one or more ATM switches.

30. The system of claim 22, where said cellular system processes joint voice-data calls.

31. The system of claim 22, wherein said vocoders are also interfaced to a public switched ATM network (PSATMN).

32. The system of claim 22, wherein said voice communication path to said PSTN is by way of said circuit-switching fabric.

33. The system of claim 22, wherein one of said plurality of call control functions is signaling conversion for interfacing SS7 signaling from a signaling network to the ATM-based call control functions.

* * * * *

US006678256B1

(12) **United States Patent**
Sato

(10) **Patent No.: US 6,678,256 B1**
(45) **Date of Patent: Jan. 13, 2004**

(54) **ATM SWITCH AND CONTROL METHOD THEREOF**

(75) Inventor: **Hiroyuki Sato**, Tokyo (JP)

(73) Assignee: **NEC Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/553,559**

(22) Filed: **Apr. 20, 2000**

(30) **Foreign Application Priority Data**

Apr. 30, 1999 (JP) 11-125231

(51) **Int. Cl.**[7] **H04B 7/00**

(52) **U.S. Cl.** **370/310.1**; 370/338; 370/395.5; 370/331; 370/467

(58) **Field of Search** 370/351, 389, 370/395.1, 360, 310.1, 338, 395.5, 395.51, 395.52, 395.53, 395.54, 400, 401, 410, 466, 467, 328, 329, 331, 310.2

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,896,386 A	*	4/1999	Johnston	370/466
5,907,542 A	*	5/1999	Kuehnel et al.	370/331
5,946,634 A	*	8/1999	Korpela	455/552.1
5,953,328 A	*	9/1999	Kim et al.	370/337
6,049,543 A	*	4/2000	Sauer et al.	370/335
6,052,371 A	*	4/2000	Lemieux	370/338
6,240,078 B1	*	5/2001	Kuhnel et al.	370/331
6,349,099 B1	*	2/2002	Larikka et al.	370/395.1
6,418,126 B1	*	7/2002	Gilmurray et al.	370/310.1
6,470,004 B1	*	10/2002	Murata	370/347
6,563,811 B2	*	5/2003	Hansen et al.	370/338
6,577,607 B1	*	6/2003	Mitts et al.	370/310.1

FOREIGN PATENT DOCUMENTS

JP	10-336205	12/1998
JP	11-55721	2/1999
JP	11-122247	4/1999

OTHER PUBLICATIONS

Leuca et al. (US PUB 2002/0041593) methods and systems for managing the routing of packets over a hybrid communication network.*

"Draft Baseline Text for Wireless ATM Capability Set 1 Specification", Dec. 19, 1998, *The ATM Forum Working Technical Committee,* Wireless ATM Working Group.

A. Acharya et al., "Mobility support of IP over wireless ATM", IEEE Communications Magazine, vol. 36, Issue 4, pp. 84–88, Apr. 1998.

S. Zhou et al., "A mobility enabled hybrid wireless network with standard ATM backbone switches: architecture implementation and performance", Wireless Communications and Networking Conference 1999, IEEE, vol. 1, pp. 388–392, Sep. 1999.

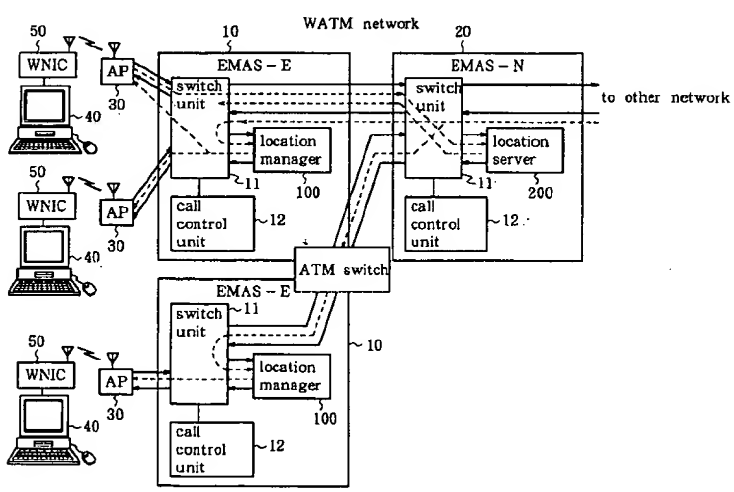
* cited by examiner

Primary Examiner—Ricky Ngo
Assistant Examiner—Yvonne Q. Ha
(74) *Attorney, Agent, or Firm*—Young & Thompson

(57) **ABSTRACT**

An ATM switch **11** is equipped with a location manager **100** or a location server **200**, which realizes the mobility supporting function of a terminal station. The location manager **100** or the location server **200** is equipped with a switching control unit **130** for performing a routing control to take all of data inputted to the ATM switch **11** in, an APCP processing unit **110** for translating a signalling signal into an APCP message, a SIG+M processing unit **120** for terminating a signalling, translating the APCP message for a communication with an access point into a SIG+M signal, which is a signalling signal added with the mobility supporting function of the terminal station, and executing the SIG+M signal and an ATM cell header conversion unit **140** for converting an ATM cell header of the SIG+M signal on demand.

7 Claims, 4 Drawing Sheets



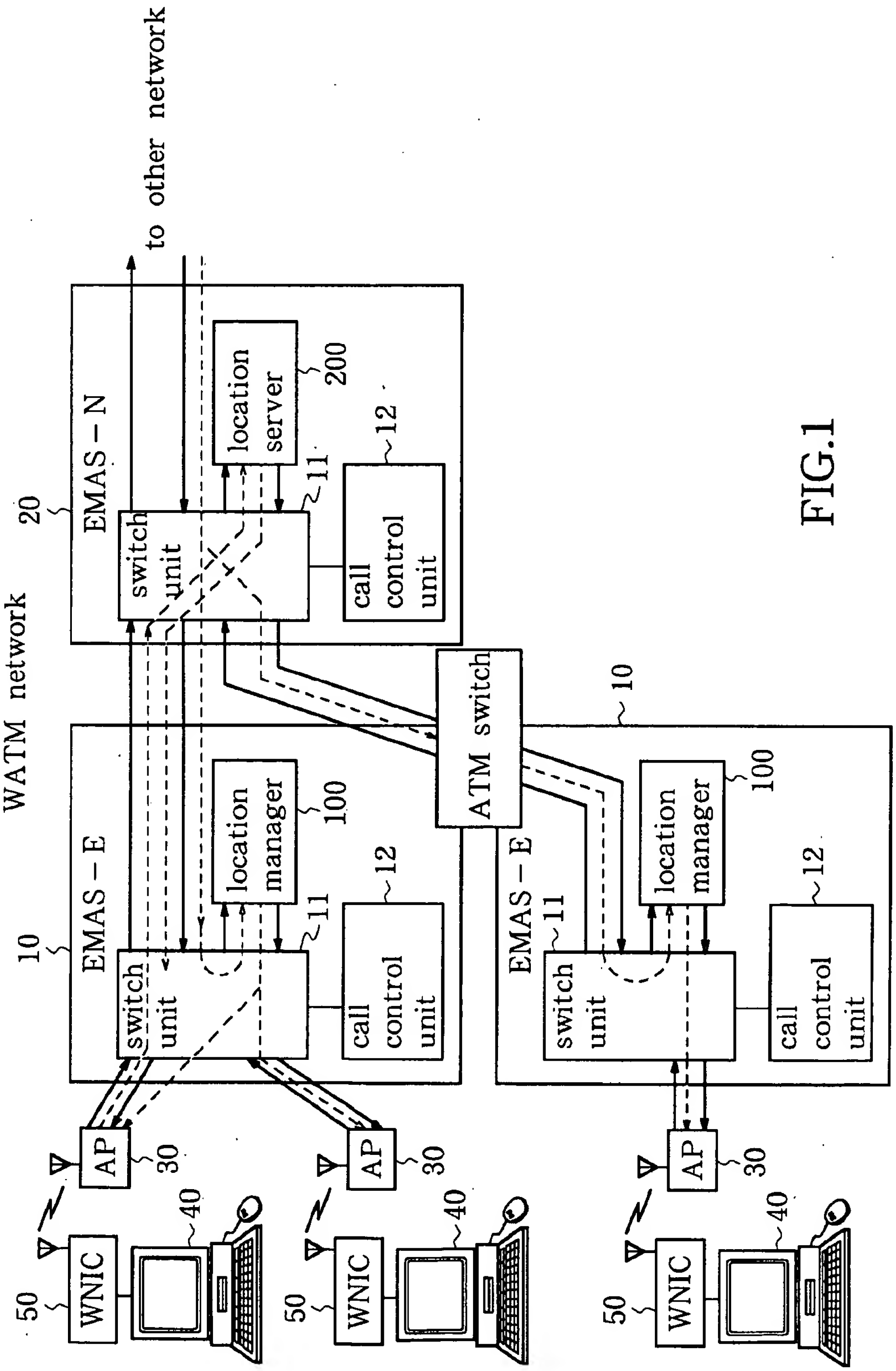

to other network
WATM network
EMAS – N
20
switch unit
11
location server
200
call control unit
12
ATM switch
10
EMAS – E
10
switch unit
11
location manager
100
call control unit
12
EMAS – E
switch unit
11
location manager
100
call control unit
12
AP
30
AP
30
AP
30
WNIC
50
40
WNIC
50
40
WNIC
50
40

FIG.1

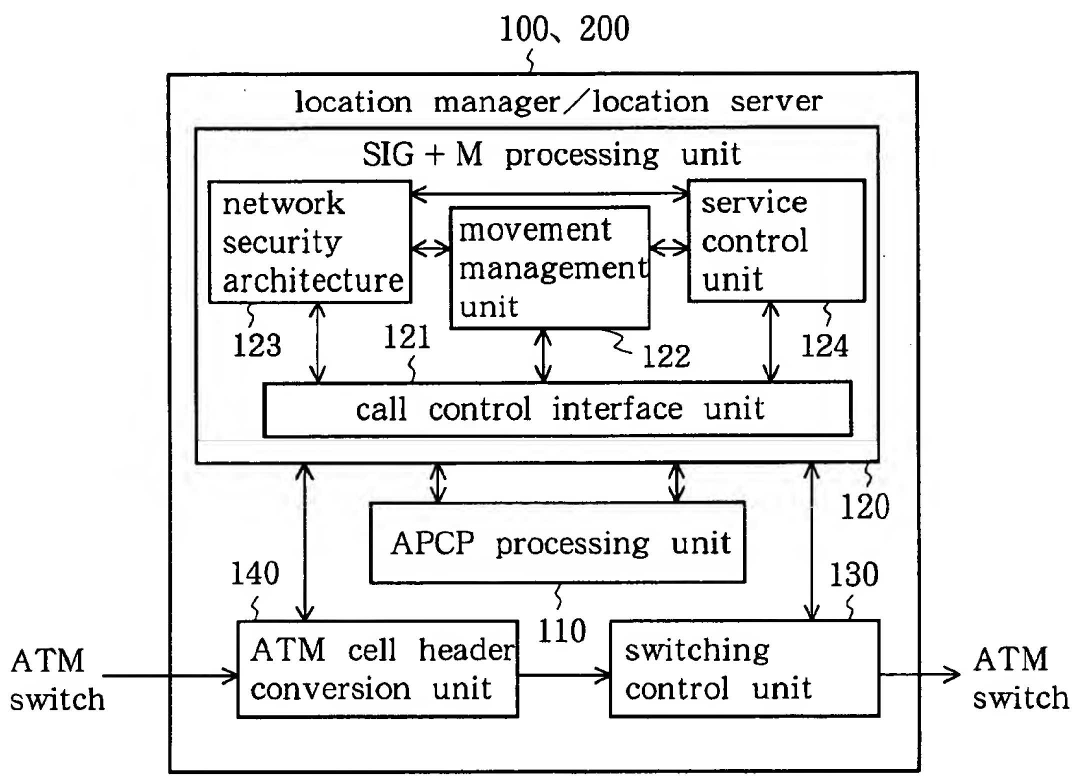

100、200
location manager／location server
SIG＋M processing unit
network security architecture
movement management unit
service control unit
123
121
122
124
call control interface unit
120
APCP processing unit
140
130
110
ATM switch
ATM cell header conversion unit
switching control unit
ATM switch

FIG.2

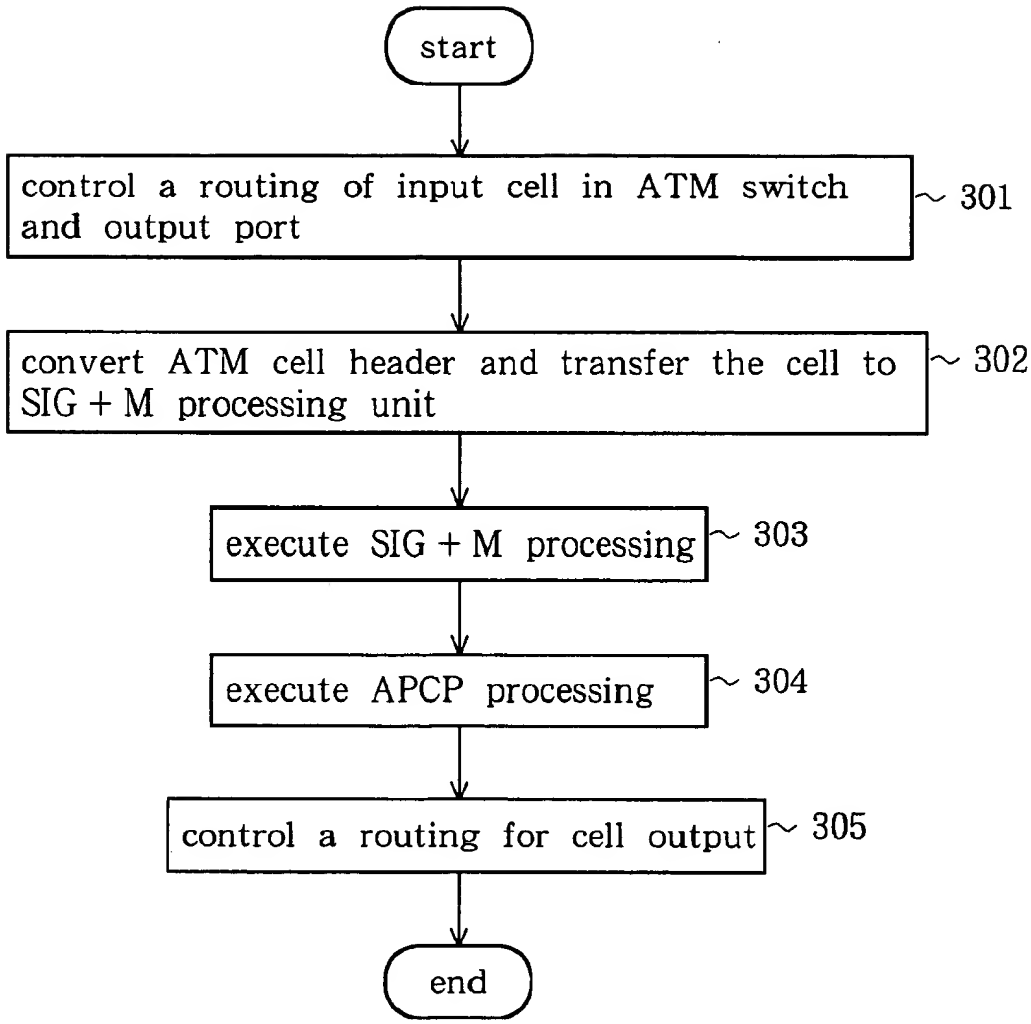

start
control a routing of input cell in ATM switch and output port
301
convert ATM cell header and transfer the cell to SIG + M processing unit
302
execute SIG + M processing
303
execute APCP processing
304
control a routing for cell output
305
end

FIG.3

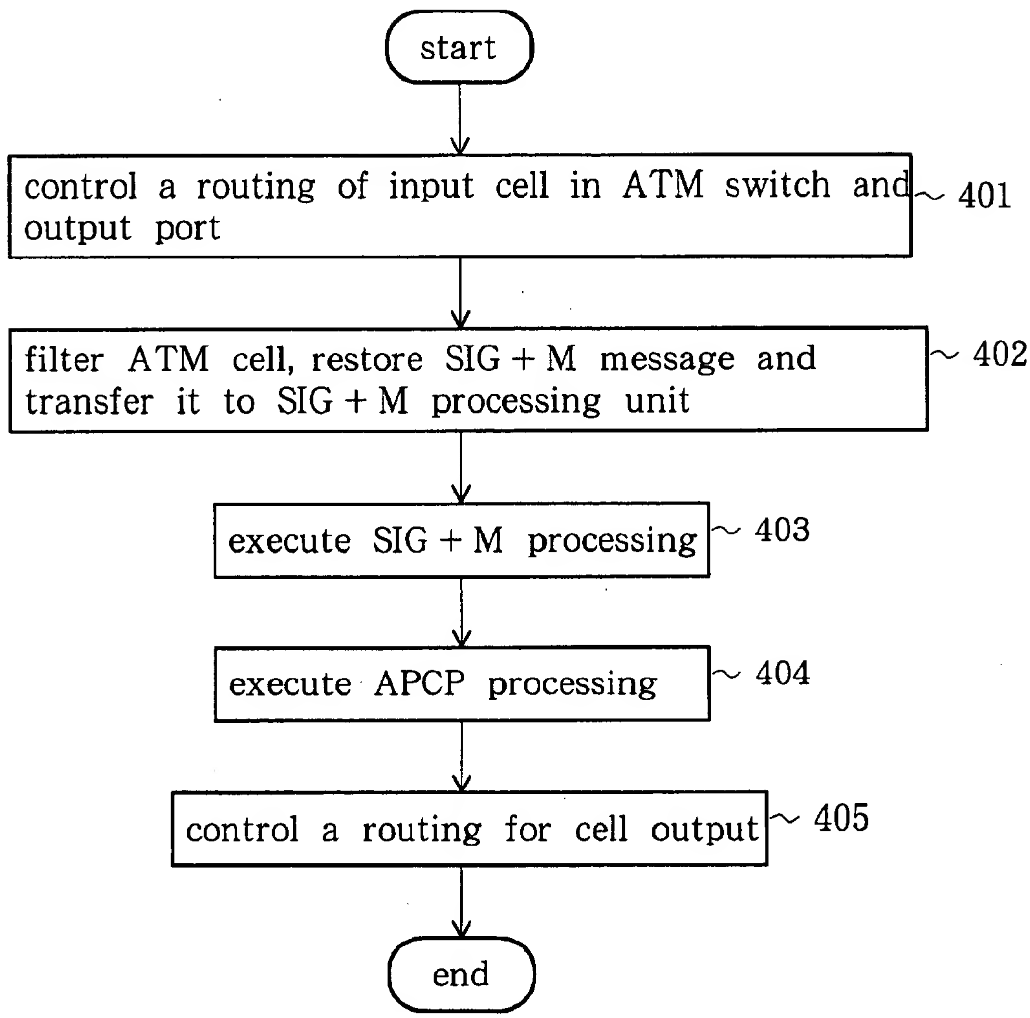

start
control a routing of input cell in ATM switch and output port
401
filter ATM cell, restore SIG + M message and transfer it to SIG + M processing unit
402
execute SIG + M processing
403
execute APCP processing
404
control a routing for cell output
405
end

FIG.4

ATM SWITCH AND CONTROL METHOD THEREOF

CROSS REFERENCE TO RELATED APPLICATIONS

The present invention claims priority from Japanese Patent Application No. 11-125231 filed Apr. 30, 1999, the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an asynchronous transfer mode (referred to as ATM, hereinafter) switch used in an ATM network system and, particularly, to an ATM switch for use in a wireless ATM (referred to as WATM, hereinafter) network system with which the mobility of terminal station is realized.

2. Description of the Related Art

As the technique for supporting a mobility of a terminal station in a WATM network system, (SIG+M), which is the existing signaling function (referred to as SIG, hereinafter) added with a mobility support function (referred to as M, hereinafter) of the terminal station, was discussed in "Wireless ATM Capability Set1 Specification-Draft BTD-WATM-01.10"; Dec. 19, 1998, Nashville, USA, ATM Forum. That is, in order to realize the WATM network system, it is necessary to construct an architecture of the end user mobility supporting ATM switch (referred to as EMAS, hereinafter) in which the signaling function (SIG+M) is applied to an SIG protocol of the existing ATM switch.

In a case where a usual ATM switch having no mobility supporting unction of a terminal station is connected to the EMAS, however, a signaling ignal (SIG signal) is terminated by the ATM switch. Therefore, a signaling ignal (SIG+M signal) having the terminal station mobility supporting function is also terminated by the ATM switch. That is, when both an EMAS and a usual ATM switch, which are multi-stage connected, exist in a WATM network, the SIG+M signal is terminated by the usual ATM switch. Therefore, it has been impossible to construct the WATM network in the network system including usual ATM switch.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an ATM switch in concord with a WATM network by providing a location manager or a location server having a mobility supporting function of a terminal station on a usual ATM switch having no mobility supporting function of the terminal station and a control method of the same ATM switch.

In order to achieve the above object of the present invention, an ATM switch used to perform a switching of ATM cells on an ATM network system in transferring the ATM cells is featured by comprising switching control means for controlling routes for switching means for executing a switching of the ATM cells required to take all input data in and routes of ports from which the input data is output, access point control protocol (APCP) processing means for translating a content of a signaling processing in a call control means into a message according to an APCP, which is a communication protocol for performing a communication with an access point, SIG+M processing means for performing a signaling termination and for executing the APCP message by translating the APCP message into the SIG+M signal, which is a signaling signal added with a mobility supporting function of a terminal station, ATM cell header conversion means for converting an ATM cell header of the SIG+M signal into virtual path identifier/virtual channel identifier (VPI/VCI) used in a user cell, inserting an identifier indicating that the converted cell is the SIG+M into a payload and transferring it to the SIG+M processing means, the ATM cell header conversion means being adapted to restore the SIG+M message and transfer it to the SIG+M processing means when a cell of the SIG+M signal converted into the VPI/VCI of the user cell header is received, the SIG+M processing means being adapted to match, as an interface with respect to the call control means, the call control means with the SIG+M processing mean, a call control interface means for recognizing a special signaling message used in the mobility supporting function of a terminal station, performing a termination processing for the special signaling message and exchanging signals with the APCP processing means. The SIG+M processing means includes movement manager for managing a movement of a terminal station, security manager for performing required security control and service control means for performing required service control.

The switching control means, the APCP processing means, the SIG+M means and the ATM cell header conversion means are provided on the network side of the switch means.

The movement manager may include a corresponding table between a location area for performing a routing control during a paging or hand-off and access points stored in the ATM switch.

Further, in order to achieve the above object of the present invention, an ATM switch control method for controlling an ATM switch used in switching in transferring ATM cells on an ATM network system is featured by comprising, in an ATM cell transfer processing requested from a terminal station in an uplink direction, the steps of controlling switch means for switching ATM cells to determine a route for taking all input data and to determine a route of an output port, converting an ATM cell header of a SIG+M signal into a VPI/VCI used in a user cell, performing a required security control and service control by recognizing a special signaling message used in a mobility supporting function of the terminal station by using the SIG+M signal converted into the VPI/VCI, performing a termination processing for the special signaling and managing a movement of the terminal station, performing, on demand, a communication with an access point by translating the signaling message into an APCP message, which is a communication protocol for communication with the access point, and using the translated APCP message, and performing an output route control of the SIG+M processed signaling message and the user cell to the network by the switch means, and, in an ATM cell transfer processing in a down-link to the terminal station, the steps of controlling switch means for switching ATM cells to determine a route for taking all input data and to determine a route of an output port, restoring the SIG+M message of a cell by receiving the cell of the VPI/VCI converted SIG+M signal of the user cell header, performing a required security control and service control by recognizing the special signaling message used in the mobility supporting function of the terminal station by using the restored SIG+M signal, performing a termination processing for the special signaling and managing a movement of the terminal station, performing, on demand, a communication with an access point by translating the signaling message into an APCP message, which is a communication protocol for communication with the access point, and using the translated APCP

message, and performing an output route control of the SIG+M processed signaling message and the user cell to the terminal station by the switch means.

In the case of the up-link ATM cell transfer processing requested by the terminal station, the step of converting the ATM cell header of the SIG+M signal into the VPI/VCI includes the step of inserting an identifier indicating that the converted cell is the SIG+M is inserted into a payload and, in the case of the down-link ATM transfer processing to the terminal station, the step of restoring the SIM+M message of a cell by receiving the cell of the SIG+M signal includes the steps of filtering the received ATM cell and restoring the SIM+M message on a basis of the identifier when the identifier inserted into a portion of the payload is detected.

Further, in order to achieve the above object of the present invention, a memory medium storing a switching control program for controlling an ATM switch used in the switching in transferring an ATM cell on an ATM network is featured by storing, in an ATM cell transfer processing requested from a terminal station in an up-link direction, the steps of controlling switch means for switching ATM cells to determine a route for taking all input data and to determine a route of an output port, converting an ATM cèll header of a SIG+M signal into a VPI/VCI used in a user cell, performing a required security control and service control by recognizing a special signaling message used in a mobility supporting function of the terminal station by using the SIG+M signal converted into the VPI/VCI, performing a termination processing for the special signaling and managing a movement of the terminal station, performing, on demand, a communication with an access point by translating the signaling message into an APCP message, which is a communication protocol for communication with the access point, and using the translated APCP message, and performing an output routing control of the SIG+M processed signaling message and the user cell to the network by the switch means, and, in an ATM cell transfer processing in a down-link to the terminal station, the steps of controlling switch means for switching ATM cells to determine a route for taking all input data and to determine a routing of an output port, restoring the SIG+M message of a cell by receiving the cell of the VPI/VCI converted SIG+M signal of the user cell header, performing a required security control and service control by recognizing the special signaling message used in the mobility supporting function of the terminal station by using the restored SIG+M signal, performing a termination processing for the special signaling and managing a movement of the terminal station, performing, on demand, a communication with an access point by translating the signaling message into an APCP message, which is a communication protocol for communication with the access point, and using the translated APCP message, and performing an output route control of the SIG+M processed signaling message and the user cell to the terminal station by the switch means.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the present invention will be described with reference to the accompanying drawings, in which:

FIG. **1** is a block diagram showing a construction of a WATM network provided with an ATM switch according to a first embodiment of the present invention;

FIG. **2** is a block diagram showing a construction of a location manager and a location server to be mounted on the ATM switch shown in FIG. **1**;

FIG. **3** is a flowchart showing a data transfer operation in an up-link direction; and

FIG. **4** is a flowchart showing a data transfer operation in a down-link direction.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the present invention, an ATM switch, which stores access point (referred to as AP, hereinafter) for storing WATM radio frequency link in a WATM network, is provided with a location manager (referred to as LM, hereinafter) having a signaling function (SIG+M) supporting the mobility of a terminal station by a location registration/authentication processing and a hand-off processing. Further, the ATM switch provided in the WATM network, for connecting to other network or other sub-network, is provided with a location server (referred to as LS, hereinafter) having a location management/authentication processing function and a function for supporting the mobility of the terminal station having a home in its own network by a hand-off processing. Each location server is provided in every network or sub-network and is provided with a location register/authentication server (LR/AUS).

In the following description, the ATM switch, which is added with the mobility supporting function of terminal station by having the location manager, will be referred to as "end user mobility supporting ATM switch—edge (EMAS-E)" and the ATM switch, which is added with the mobility supporting function of the terminal station by having the location server, will be referred to as "end user mobility supporting ATM switch—network (EMAS-N)".

FIG. **1** is a block diagram showing a construction of a WATM network having an EMAS-E and an EMAS-N, which are the ATM switches according to an embodiment of the present invention. Referring to FIG. **1**, each EMAS-E **10** accommodating a plurality of access points (AP's) **30** includes a switch unit **11** for executing a switching between ATM cells, a call control unit **12** which is used for establishing, maintaining, modifying and releasing a call and a connection but does not support mobility of terminal stations, and a location manager **100** for realizing the mobility supporting function of a terminal station by extending the SIG+M function. An EMAS-N **20** for connecting the EMAS-E's **10** to another network includes a switch unit **11** for executing a switching between the ATM cells, a call control unit **12** and a location server **200** for realizing the mobility supporting function of a terminal station by extending the SIG+M function.

As shown in FIG. 1, the location manager **100** of the EMAS-E **10** and the location server **200** of the EMAS-N **20** are arranged on the network sides of the switch units **11**, respectively. Further, in the WATM network shown in FIG. 1, each mobile terminal (MT) **40** is connected to a corresponding access point **30** through a wireless network interface card (WNIC) **50**. It should be noted that FIG. **1** shows only construction specific to this embodiment, without other general construction.

FIG. **2** is a block diagram showing a construction of the location manager **100** or the location server **200**. It should be noted that the construction of the location manager **100** is identical to that of the location server **200**.

Referring to FIG. **2**, the location manger **100** or the location server **200** includes an APCP processing unit **110** for performing a communication with the access point **30**, an SIG+M processing unit **120** for realizing the SIG+M

function, a switching control (SW-CNT) unit **130** for performing a route control of the switch unit **11** and an ATM cell header conversion (HCV) **140** for performing a conversion processing of the ATM cell header. In a case where the EMAS-E **10** and the EMAS-N **20** are to be realized by data processing devices, that is, computers, the location manager **100** and the location server **200** are realized by program-controlled CPU's of the data processing devices, respectively. A computer program for controlling the CPU's is stored in a magnetic disk, an optical disk, a semiconductor memory or other general memory medium and loaded in an internal memory of the data processing unit to control the CPU's to thereby realize respective constructive components of the location manager **100** and the location server **200**.

The APCP processing unit **110** performs the SIG+M termination processing in not the access point **30** but the location manager **100** of the EMAS-E **10**. Therefore, it is mounted with the APCP for performing a communication between the access point **30** and the location manager **100**. In order to use the APCP, a content of the signaling processing for performing a management, such as management of radio resources, of the access point **30** in the location manager **100** is translated into an APCP message. The SIG+M processing unit **120** performs the SIG+M termination processing and translates the APCP message for performing a communication with the access point **30** into a SIG+M signal and executes it. As shown in FIG. **2**, the SIG+M processing unit **120** includes a call control interface unit (CC+M) **121**, which is an interface between the call control portion **12** and the SIG+M processing unit **120**, a mobility management function (F) unit **122** for managing a movement of the terminal station **40**, a network security administration (NSA) unit **123** for performing a security management and a service control function (SCF) unit **124** for performing a predetermined service control. Incidentally, the location registration/authentication function and the hand-off function are realized by the SIG+M processing. The SIG+M protocol is based on the functional construction studied in the previously mentioned ATM Forum.

The call control interface unit **121** provides, as a logic interface, a matching between the call control unit **12** of the switch unit **11**, which does not support the mobility of the terminal station **30**, and the location manager **100** or the location server **200**. Further, the call control interface unit **121** recognizes a specific signaling message used to support the mobility of the terminal station **40**, terminates the signaling message and exchanges signals with the APCP processing unit **110**. All communications between the APCP processing unit **110** and the SIG+M processing unit **120** are performed through the call control interface unit **121**. The function of the call control interface unit **121** is not the function of the call control unit of the existing ATM switch extended to have a function of supporting the mobility of the terminal station, but a minimum control function required to perform the SIG+M signaling processing.

The mobility management function unit **122** manages the movement of the terminal station **40**. The mobility management function unit **122** includes a correspondence table storing a relation between a location area for performing a routing control in a case of paging or hand-off and the access points **30** included in the switch unit **11**.

The security management unit **123** performs a hiding control of an information such as verification for authentication of terminal station and message authentication.

The service control unit **124** manages service data and service profile.

The switching control unit **130** controls a routing within the switch unit **11** such that the signaling message input to the switch unit **11** is not terminated therein. That is, in order to prevent the signaling message from being terminated in the ATM switch of the location manager **100** or the location server **200** and to send/receive cells having cell headers converted into ATM cell headers, the switching control unit **124** performs a control of routing for taking in all data inputted to the switch unit **11**. Further, in outputting the taken data to the location manager **100** or the location server **200**, the switching control unit **124** controls a routing of the data within the switch unit **11** and to the output ports of the switch unit **11**.

In a case where ATM switches, which have no mobility supporting function of terminal station, are connected in multi-stage manner between the EMAS-E **10** and the EMAS-N **20**, which have the mobility supporting function, it is unnecessary to constitute all of the ATM switches with EMAS-E's each including the location manager **100** and EMAS-N's each including the location server **200** by performing the switching control such that the message is not SIG+M terminated. That is, it is enough to constitute the WATM network with the ATM switches, only the ATM switch including the access points and the ATM switch including the location registration server and the authentication server of which are constituted with the EMAS-E **10** and the EMAS-N **20**, respectively.

By taking the case where ATM switches, which have no mobility supporting function of terminal station, are connected in multi-stage manner between the EMAS-E **10** and the EMAS-N **20**, which have the mobility supporting function into consideration, the ATM cell header conversion unit **140** converts the ATM cell header of the SIG+M signal into the VPI/VCI used in the user cell such that all of the SIG+M signals exchanged between the EMAS-E **10** and the EMAS-N **20** are considered as user cells. Further, the identifier indicating that the converted cell is the SIG+M signal is inserted into the payload. That is, all of the data inputted to the switch unit **11** are filtered by the ATM cell header conversion unit **140**. Further, when the ATM cell header conversion unit **140** receives a cell of the SIG+M signal whose header is converted into the VPI/VCI of the user cell header, the ATM cell header conversion unit **140** restores the SIG+M message of the cell and transfers the restored SIG+M message to the SIG+M processing unit **120**.

An operation of this embodiment of the present invention will be described with reference to flowcharts shown in FIGS. **3** and **4**, in which FIG. **3** is a flowchart showing an ATM cell transfer processing in an up-link direction in the EMAS-E **10**, that is, in the direction from the terminal station **40** to the EMAS-E **10**, and FIG. **4** is a flowchart showing an ATM cell transfer processing in a down-link direction in the EMAS-E **10**, that is, the direction from the EMAS-E **10** to the terminal station **40**.

Describing the up-link ATM cell transfer processing with reference to FIG. **3**, the switching control unit **130** of the location manager **100** extracts a connection control information, which is processed by the call control interface unit **121**, from an ATM cell received from the terminal station **40** through the wireless network interface card **50** and the access point **30**, performs the switching control of the ATM switch by referencing the extracted connection control information and performs the routing control such that the ATM cell outputted by the EMAS-E **10** is outputted to the port for the location manager **100** under the switching control of the ATM switch (step **301**).

Upon the reception of the ATM cell, the location manager **100** extracts the SIG+M message from the ATM cell by the

ATM cell header conversion unit **140** and converts the SIG+M signal into an ATM cell header having the VPI/VCI value, which is not terminated by the switch unit **11**, by the ATM cell header conversion unit **140**, inserts the identifier indicating that the converted cell is the SIG+M into the payload and transfers it to the SIG+M processing unit **120** (step **302**).

Then, in the SIG+M processing unit **120**, a PDU is transmitted/received by the call control interface unit **121** as an interface for a lower layer to perform a communication with other function entities (**122~124**) belonging to the SIG+M processing unit **120** according to the processing content of the respective SIG+M messages, performs the termination processing of a specific signaling by recognizing the specific signaling message used in the mobility supporting function of the terminal station, manages the movement of the terminal station and executes a required processing such as security control or service control (step **303**).

In regard to the SIG+M processing related to the management of the access point **30**, such as security and release of wireless resources, etc., the SIG+M message is translated into the APCP message and the APCP message is transferred to the APCP processing unit **110** (step **304**).

Finally, the signaling message and the user cell, which are SIG+M processed, are sent to the switch unit **11** and the routing control is performed by the call control interface unit **121** and the switching control unit **130** such that the signaling message and the user cell are outputted to the network side by the switch unit **11** (step **305**).

The above mentioned operation is the operation of the location manager **100** mounted on the EMAS-E **10** in the case where the ATM cell is transferred from the terminal station **40** to the EMAS-E **10** and further transferred from the EMAS-E **10** to the EMAS-N **20**. It should be noted that the operation of the location server **200** when the ATM cell is transferred from the EMAS-E **10** to the EMAS-N **20** and further transferred from the EMAS-N **20** to other network is the same as that of the operation of the location manager **100**.

Now, the ATM cell transfer processing in the down-link direction will be described with reference to FIG. **4**. First, the switching control unit **130** of the location manager **100** extracts the connection control information to be processed by the call control interface unit **121** from the ATM cell received from the EMAS-N **20** and performs a switching control of the switch unit **11** by referencing the extracted connection control information to control the routing such that the ATM cell outputted from the EMAS-E **10** is outputted to the port corresponding to the location manager **100** (step **401**).

Upon the reception of the ATM cell, the location manager **100** filters the ATM cell by the ATM cell header conversion unit **140**, restores the SIG+M message on the basis of the identifier inserted into a portion of the payload and transfers it to the SIG+M processing unit **120** (step **402**).

Then, in the SIG+M processing unit **120**, the call control interface unit **121** becomes an interface for the lower layers and transmits/receive the PDU to perform a communication with other function entities (**122~124**) belonging to the SIG+M processing unit **120** according to the processing content of the respective SIG+M messages to thereby execute the respective processing (step **403**).

In regard to the SIG+M processing related to the management of the access point **30**, such as security and release of wireless resources, etc., the SIG+M message is translated into the APCP message and the APCP message is transferred to the APCP processing unit **110** (step **404**).

Finally, the signaling message and the user cell, which are SIG+M processed, are sent to the switch unit **11** and the routing control is performed by the call control interface unit **121** and the switching control unit **130** such that the signaling message and the user cell are outputted to the network side by the switch unit **11** (step **405**).

The above mentioned operation is the operation of the location manager **100** mounted on the EMAS-E **10** in the case where the ATM cell is transferred from the EMAS-N **20** to the EMAS-E **10** and further transferred from the EMAS-E **10** to the terminal station **40**. It should be noted that the operation of the location server **200** of the EMAS-N **20** when the ATM cell is transferred from other network to the EMAS-N **20** and further transferred to the EMAS-E **10** is the same as that of the operation of the location manager **100**.

The operations mentioned above are also applied to the routing during the hand-off and the SIG+M processing in the location registration processing.

Although the present invention has been described with reference to the preferred embodiments, the present invention is not always limited to these embodiments. For example, in order to provide the mobility supporting function of the terminal station, which is necessary to construct the WATM network, the location manager or the location server may be provided not on the network side of the ATM switch but on the terminal station side of the ATM switch. In such case, however, it is necessary to add a specific operation such as insertion of a buffer, etc., to the routing control in the ATM switch.

As described hereinbefore, according to the ATM switch and the control method thereof and the recording medium storing the switching control program of the present invention, it becomes possible to easily make the ATM switch having no mobility supporting function adaptable to the WATM network by providing the location manager or the location server having the mobility supporting function on the ATM switch.

Further, since, in order to construct the WATM network in a case where ATM switches, which have no mobility supporting function of terminal station, are connected in multistage manner between the EMAS-E **10** and the EMAS-N **20**, which have the mobility supporting function, it is necessary to provide the location managers or the location servers on not all of the ATM switches but only ATM switch including the access points and ATM including the location registration sever or the authentication server, it is easily possible to construct the WATM network by executing an extension of the function of the ATM switch.

The processing load to be carried on the access points is reduced by assigning the wireless resources by the APCP processing unit of the location manager or the location server without performing the signalling processing in the access points and, further, since the user network interface (UNI) signalling message is not used, it becomes possible to use same access points for various networks including such as WATM network, the existing ATM network and IP network, etc., the extendibility is improved.

What is claimed is:

1. An ATM switch used to perform a switching of ATM cells on an ATM network system in transferring the ATM cells, comprising:

switch means for switching a transfer route of a cell on the ATM network system;

switching control means for controlling a routing in said switch means for executing a switching of the ATM cells required to take all input data in and a routing to one of ports from which the input data is output;

call control means for establishing a connection in the ATM network;

APCP processing means for translating a content of a signalling processing in said call control means into an APCP message according to an access point control protocol, which is a communication protocol for performing a communication with access points;

SIG+M processing means for performing a signalling termination and for translating the APCP message into a SIG+M signalling signal by adding the mobility supporting function of terminal station thereto and executing the SIG+M signalling signal;

ATM cell header conversion means for converting an ATM cell header of the SIG+M signal into VPI/VCI used in a user cell, inserting an identifier indicating that the converted cell is the SIG+M into a payload and transferring it to said SIG+M processing means, said ATM cell header conversion means being adapted to restore the SIG+M message and transfer it to said SIG+M processing means when a cell of the SIG+M signal converted into the VPI/VCI of the user cell header is received;

said SIG+M processing means comprising call control interface means for matching between said call control means and said SIG+M processing means, for recognizing a special signaling message used in the mobility supporting function of a terminal station, performing a termination processing for the special signaling message and exchanging signals with said APCP processing means.

2. An ATM switch as claimed in claim 1, wherein said switching control means, said APCP processing means, said SIG+M means and said ATM cell header conversion means are provided on the network side of said switch means.

3. An ATM switch as claimed in claim 1, wherein said movement management means includes a correspondence table between a location area for performing a routing control during a paging or hand-off and access points stored in the ATM switch.

4. An ATM switch control method for controlling an ATM switch used in switching in transferring ATM cells on an ATM network system, comprising, in an ATM cell transfer processing requested from a terminal station in an up-link direction, the steps of:

controlling switch means for switching ATM cells to determine a route for taking all input data and to determine a route of an output port;

converting an ATM cell header of a SIG+M signal into a VPI/VCI used in a user cell;

performing a required security control and service control by recognizing a special signaling message used in a mobility supporting function of the terminal station by using the SIG+M signal converted into the VPI/VCI, performing a termination processing for the special signaling and managing a movement of the terminal station, performing, on demand, a communication with an access point by translating the signaling message into an APCP message, which is a communication protocol for communication with the access point, and using the translated APCP message, and performing an output route control of the SIG+M processed signaling message and the user cell to the network by the switch means, and comprising, in an ATM cell transfer processing in a down-link to the terminal station, the steps of:

controlling switch means for switching ATM cells to determine a route for taking all input data and to determine a route of an output port;

restoring the SIG+M message of a cell by receiving the cell of the VPI/VCI converted SIG+M signal of the user cell header;

performing a required security control and service control by recognizing the special signaling message used in the mobility supporting function of the terminal station by using the restored SIG+M signal;

performing a termination processing for the special signaling and managing a movement of the terminal station;

performing, on demand, a communication with an access point by translating the signaling message into an APCP message, which is a communication protocol for communication with the access point, and using the translated APCP message; and

performing an output routing control of the SIG+M processed signaling message and the user cell to the terminal station by the switch means.

5. An ATM switch control method as claimed in claim 4, wherein the step of converting an ATM cell header of a SIG+M signal into a VPI/VCI in the case of the up-link ATM cell transfer processing requested by the terminal station, comprises the step of inserting an identifier indicating that the converted cell is the SIG+M into a payload and the step of restoring the SIG+M message of a cell by receiving the cell of the VPI/VCI converted SIG+M signal in the case of the down-link ATM transfer processing to the terminal station, comprising step of filtering the received ATM cell and, when the identifier inserted into a portion of the payload is detected, restoring the SIM+M message of the cell on a basis of the identifier.

6. A memory medium storing a switching control program for controlling an ATM switch used in the switching in transferring an ATM cell on an ATM network, said switching control program comprising, in an ATM cell transfer processing requested from a terminal station in an up-link direction, the steps of:

controlling a routing of switch means for executing the switching of the ATM cells to take all input data inputted thereto and of a port to output the input data;

converting an ATM cell header of a SIG+M signal into a VPI/VCI used in a user cell;

performing a required security control and service control by recognizing a special signalling message used in a mobility supporting function of the terminal station by using the SIG+M signal converted into the VPI/VCI, performing a termination processing for the special signalling and managing a movement of the terminal station;

performing, on demand, a communication with an access point by translating the signalling message into an APCP message, which is a communication protocol for communication with the access point, and using the translated APCP message; and

performing an output routing control of the SIG+M processed signalling message and the user cell to said network by said switch means, and, in an ATM cell transfer processing in a down-link to the terminal station, the steps of:

controlling a routing of said switch means for switching ATM cells to take all input data inputted thereto and of a port to output the input data;

restoring the SIG+M message of a cell by receiving the cell of the VPI/VCI converted SIG+M signal of the user cell header;

performing a required security control and service control by recognizing the special signalling message used in the mobility supporting function of the terminal station by using the restored SIG+M signal, performing a termination processing for the special signaling and managing a movement of the terminal station;

performing, on demand, a communication with an access point by translating the signalling message into an APCP message, which is a communication protocol for communication with the access point, and using the translated APCP message; and

performing an output routing control of the SIG+M processed signalling message and the user cell to the terminal station by said switch means.

7. A recording medium as claimed in claim 6, wherein the step of converting an ATM cell header of a SIG+M signal into a VPI/VCI in the case of the up-link ATM cell transfer processing requested by the terminal station, comprises the step of inserting an identifier indicating that the converted cell is the SIG+M into a payload and the step of restoring the SIG+M message of a cell by receiving the cell of the VPI/VCI converted SIG+M signal in the case of the down-link ATM transfer processing to the terminal station, comprises step of filtering the received ATM cell and, when the identifier inserted into a portion of the payload is detected, restoring the SIM+M message of the cell on a basis of the identifier.

* * * * *

US006477154B1

(12) United States Patent
Cheong et al.

(10) Patent No.: **US 6,477,154 B1**

(45) Date of Patent: **Nov. 5, 2002**

(54) **MICROCELLULAR MOBILE COMMUNICATION SYSTEM**

(75) Inventors: **Jong Min Cheong**, Seoul (KR); **Tae Gue Kim**, Seoul (KR); **Sang Hoon Seo**, Seoul (KR); **Jae Sung Lim**, Seoul (KR); **Sun Park**, Seoul (KR)

(73) Assignee: **SK Telecom Co., Ltd.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/138,470**

(22) Filed: **Aug. 14, 1998**

(30) **Foreign Application Priority Data**

Aug. 14, 1997 (KR) 97-38788

(51) **Int. Cl.**[7] **H04B 7/216**; H04J 3/16; H04J 14/00; H04Q 7/00; H04Q 7/20

(52) **U.S. Cl.** **370/328**; 370/467; 359/109; 359/115; 359/118; 375/130; 375/140; 375/257; 455/444; 455/436; 455/439

(58) **Field of Search** 370/320, 328, 370/331, 334, 335, 342, 467; 359/109, 115, 118, 135–136; 375/130, 140, 257; 455/436, 439, 442, 444, 450–452

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,280,472 A * 1/1994 Gilhousen et al. 370/18
5,303,287 A * 4/1994 Laborde 379/59
5,400,391 A * 3/1995 Emura et al. 379/59
5,424,864 A * 6/1995 Emura 359/172
5,761,619 A * 6/1998 Danne et al. 455/422
5,969,837 A * 10/1999 Farber et al. 359/132

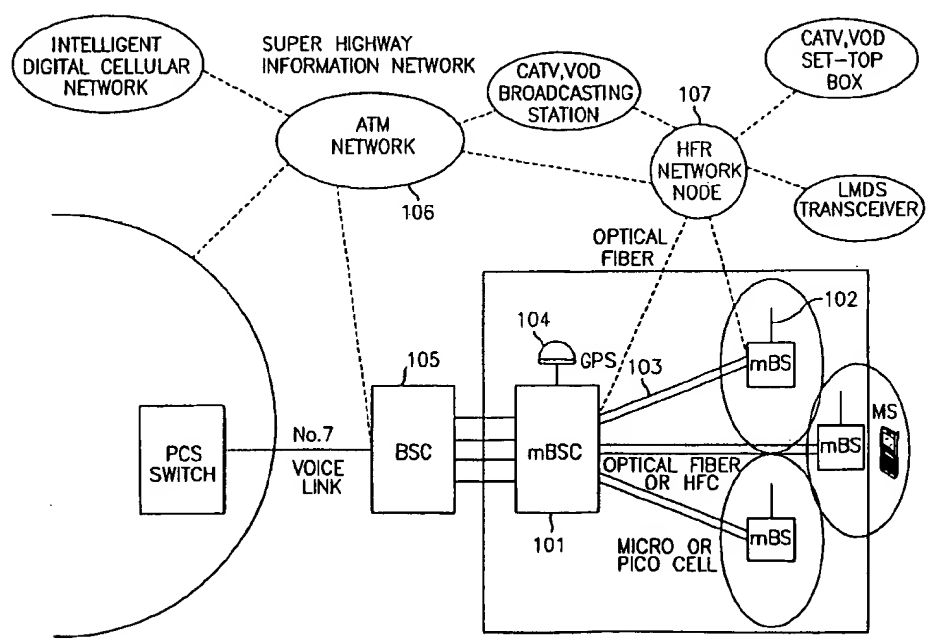
* cited by examiner

Primary Examiner—Alpus H. Hsu
Assistant Examiner—Toan Nguyen
(74) *Attorney, Agent, or Firm*—Sheridan Ross P.C.

(57) **ABSTRACT**

A microcelluar mobile communication system which performs various functions such as a centralized management of resources, a capacity increase, a Base Station Transceiver System(BTS) miniaturization, a synchronization between micro base stations, a dynamic resource management, a softer handover between cells, a grouping and ungrouping of base stations in accordance with a traffic distribution. The microcelluar mobile communication system may increase the subscriber capacity, provide the high reliable service, extend the battery life of a personal station inducing low power communication and assure the radio channel capacity so that the radio multimedia service may be accomplished in the future, by maximizing the utility efficiency of radio frequency resource through cell miniaturization. The microcelluar mobile communication system may be installed efficiently to an indoor, a building underground, an underground tunnel as well as an outdoor, and may compose the single cell also in the indoor.

21 Claims, 8 Drawing Sheets



02/05/2004, EAST Version: 1.4.1

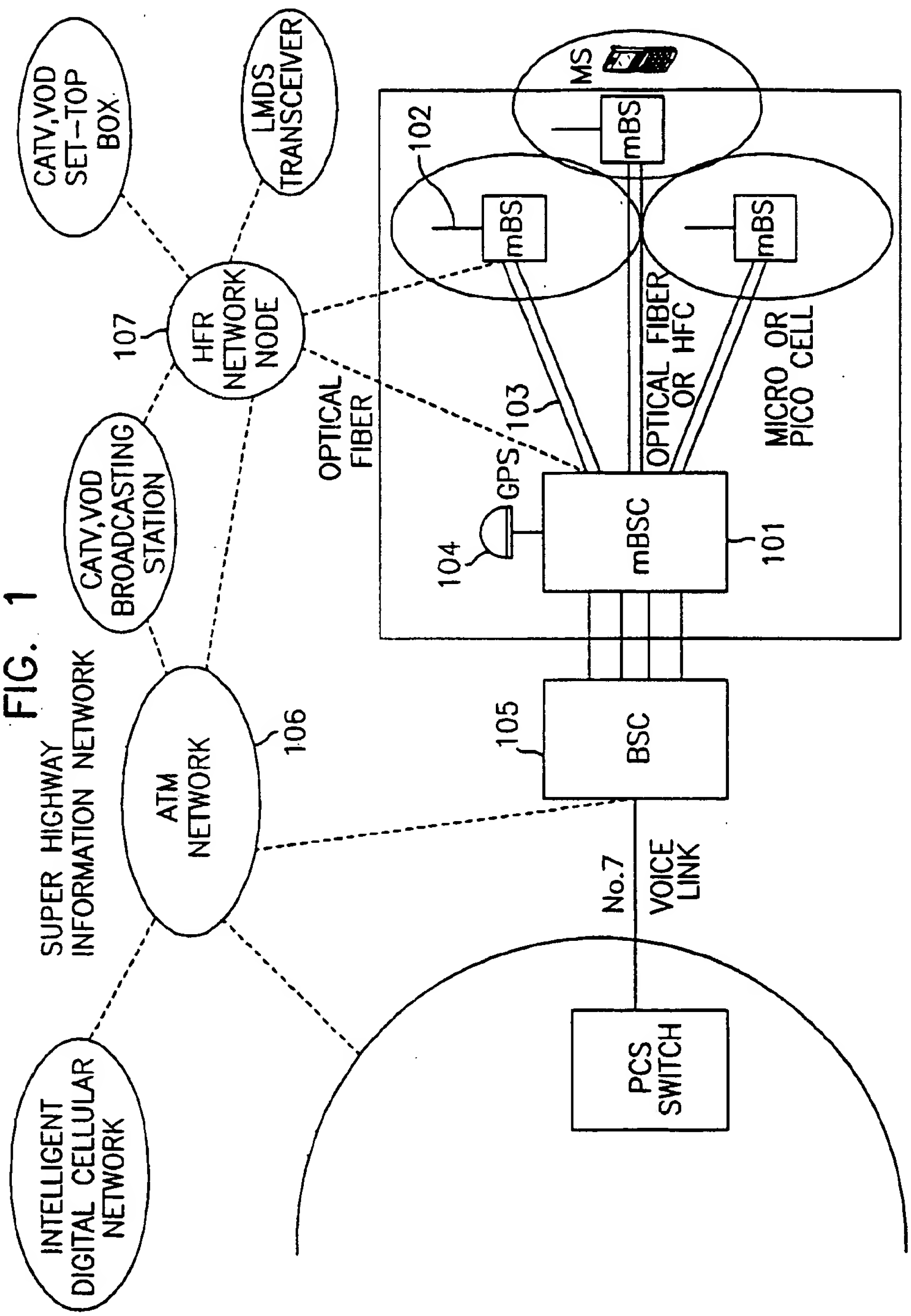

SUPER HIGHWAY INFORMATION NETWORK
CATV,VOD SET-TOP BOX
LMDS TRANSCEIVER
HFR NETWORK NODE
107
CATV,VOD BROADCASTING STATION
ATM NETWORK
106
INTELLIGENT DIGITAL CELLULAR NETWORK
OPTICAL FIBER
MS
mBS
mBS
mBS
102
103
GPS
104
mBSC
101
OPTICAL FIBER OR HFC
MICRO OR PICO CELL
BSC
105
No.7
VOICE LINK
PCS SWITCH

FIG. 1

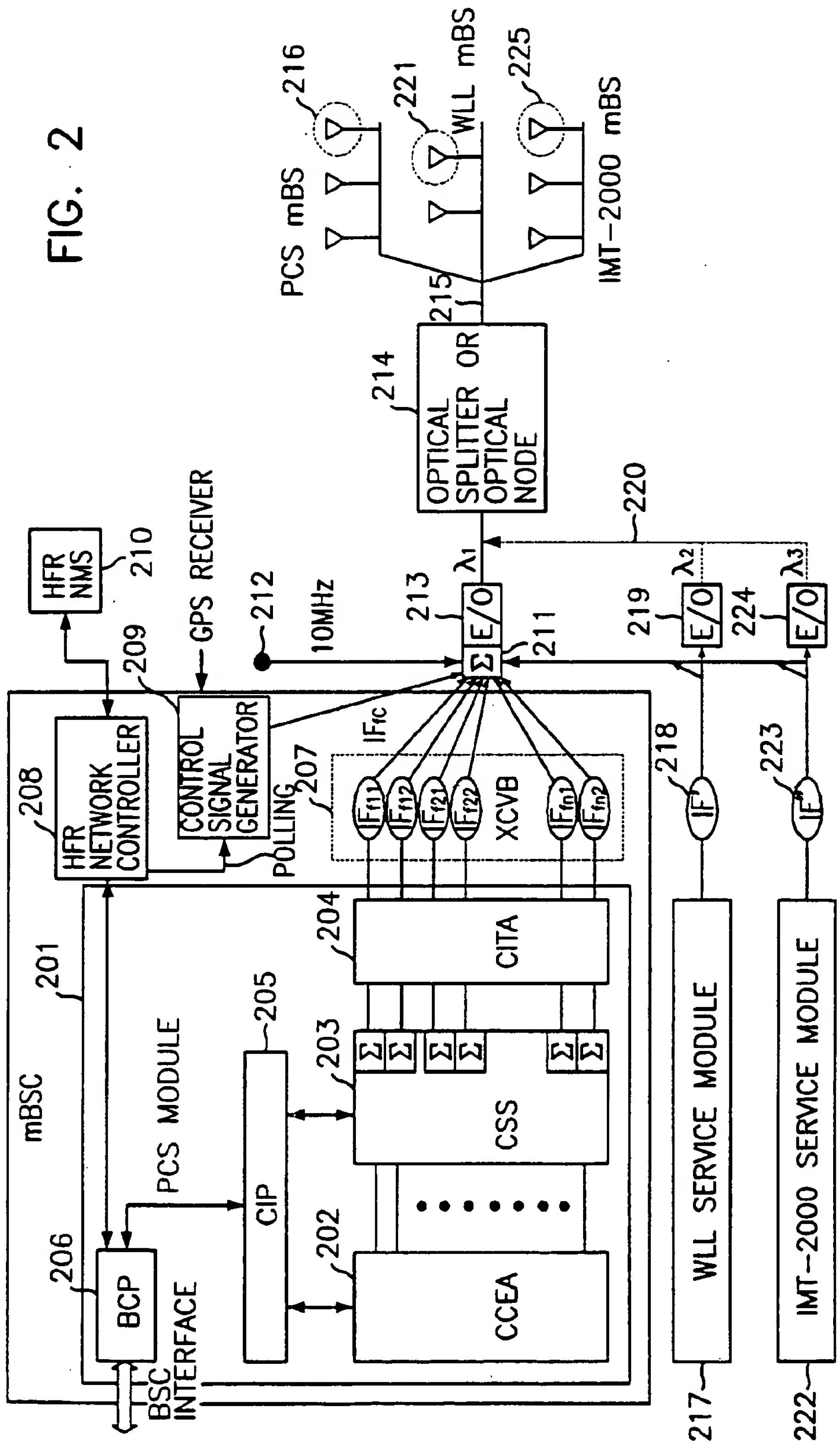

PCS mBS
216
221
WLL mBS
225
IMT-2000 mBS
215
214
OPTICAL SPLITTER OR OPTICAL NODE
220
HFR NMS
210
GPS RECEIVER
212
10MHz
213
λ1
λ2
λ3
E/O
Σ
211
219
224
209
208
HFR NETWORK CONTROLLER
CONTROL SIGNAL GENERATOR
POLLING
207
IFfc
XCVB
218
223
IF
204
CITA
201
205
203
CSS
CIP
PCS MODULE
mBSC
202
CCEA
206
BCP
BSC INTERFACE
WLL SERVICE MODULE
IMT-2000 SERVICE MODULE
217
222

FIG. 2

FIG. 3A

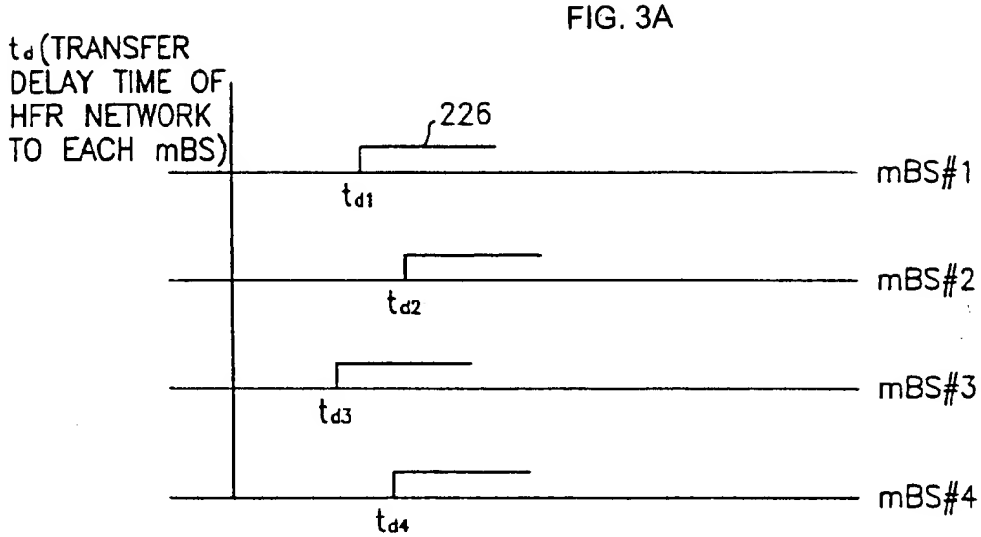

t_d (TRANSFER DELAY TIME OF HFR NETWORK TO EACH mBS)
226
t_{d1}
mBS#1
t_{d2}
mBS#2
t_{d3}
mBS#3
t_{d4}
mBS#4

FIG. 3B

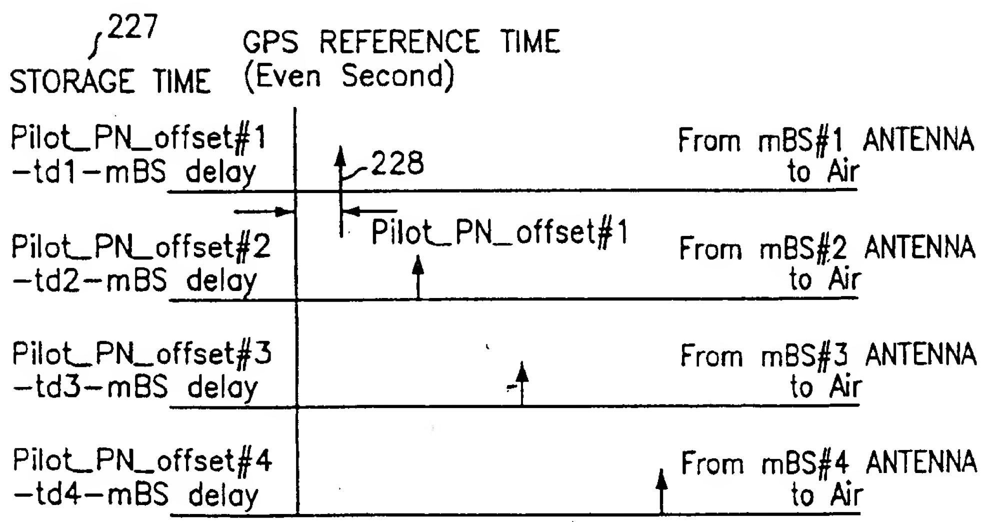

227
STORAGE TIME
GPS REFERENCE TIME (Even Second)
Pilot_PN_offset#1 −td1−mBS delay
228
From mBS#1 ANTENNA to Air
Pilot_PN_offset#1
Pilot_PN_offset#2 −td2−mBS delay
From mBS#2 ANTENNA to Air
Pilot_PN_offset#3 −td3−mBS delay
From mBS#3 ANTENNA to Air
Pilot_PN_offset#4 −td4−mBS delay
From mBS#4 ANTENNA to Air

FIG. 4

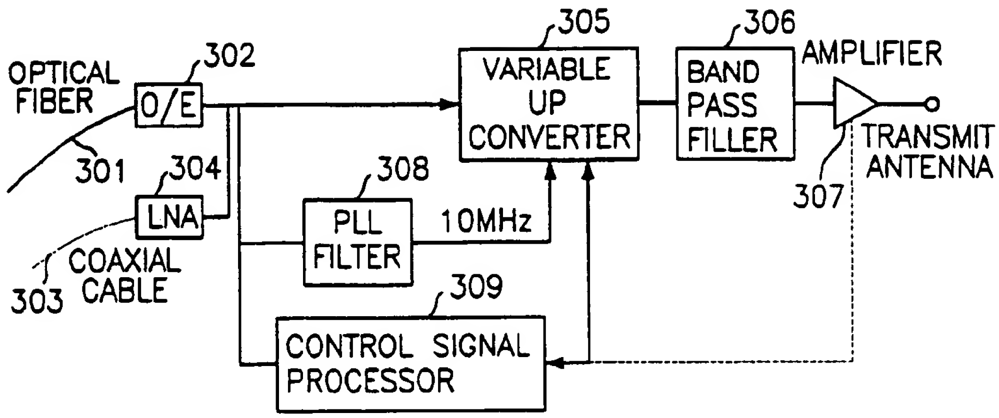


FIG. 5A

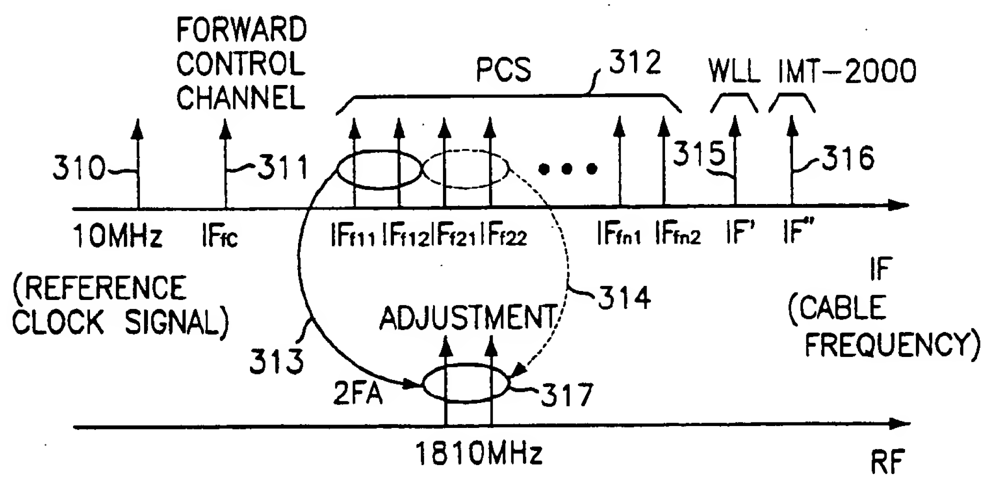


FIG. 5B

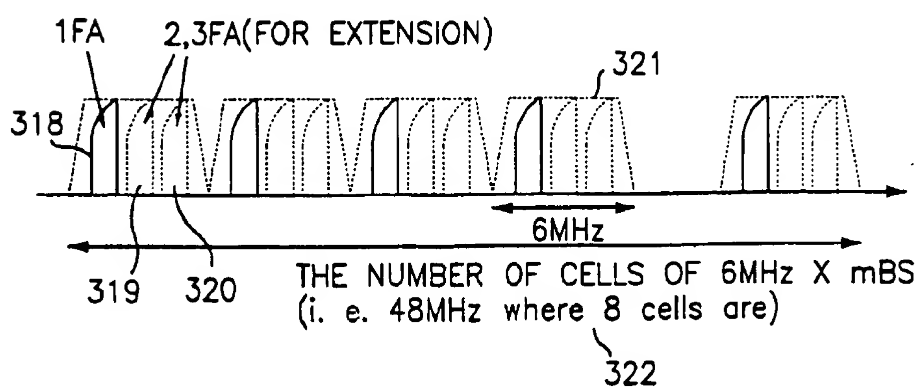


FIG. 6

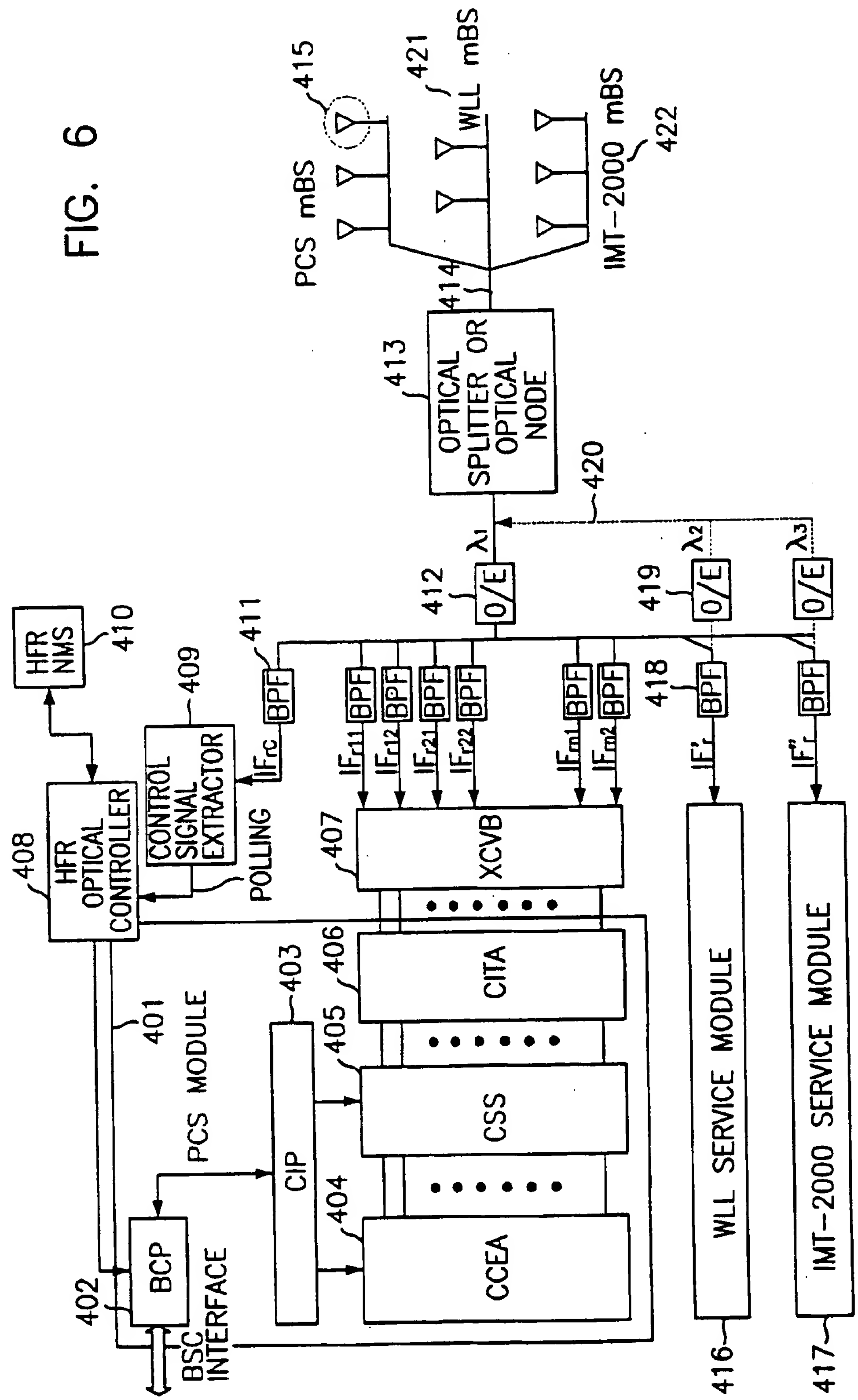

PCS mBS
415
421
WLL mBS
IMT-2000 mBS
422
414
413
OPTICAL SPLITTER OR OPTICAL NODE
420
λ1
λ2
λ3
412
O/E
419
O/E
O/E
HFR NMS
410
409
411
BPF
CONTROL SIGNAL EXTRACTOR
IFrc
IFr11
IFr12
IFr21
IFr22
IFrn1
IFrn2
418
BPF
IF'r
IF"r
408
HFR OPTICAL CONTROLLER
POLLING
407
XCVB
406
CITA
403
405
CSS
401
PCS MODULE
CIP
404
CCEA
402
BCP
BSC INTERFACE
WLL SERVICE MODULE
IMT-2000 SERVICE MODULE
416
417

FIG. 7

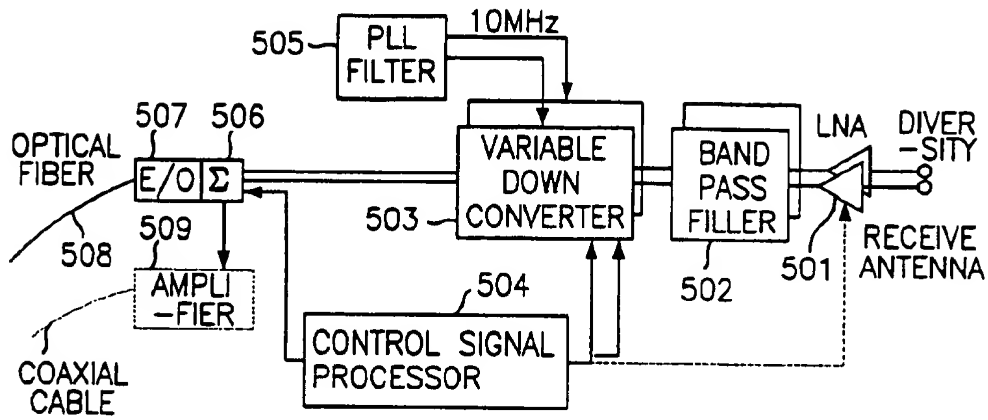


FIG. 8A

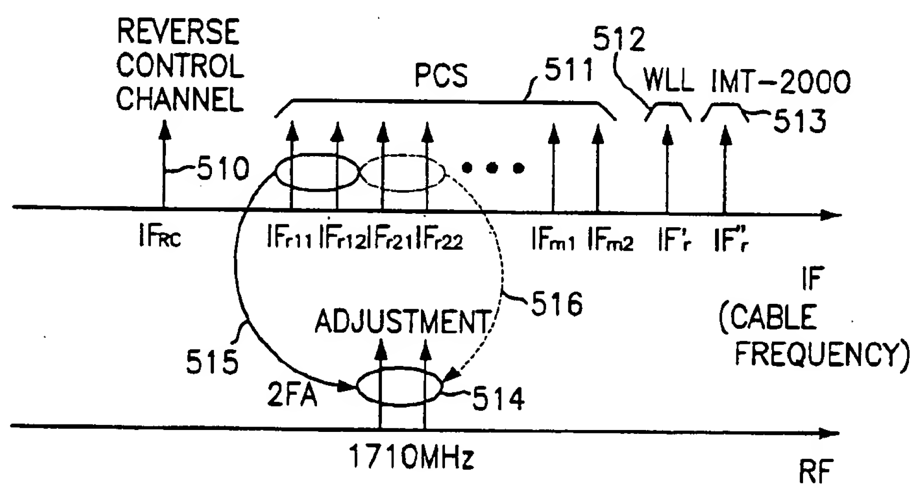


FIG. 8B

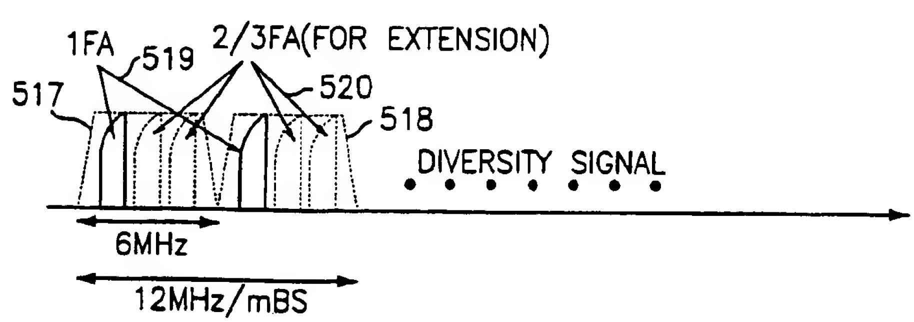


FIG. 9

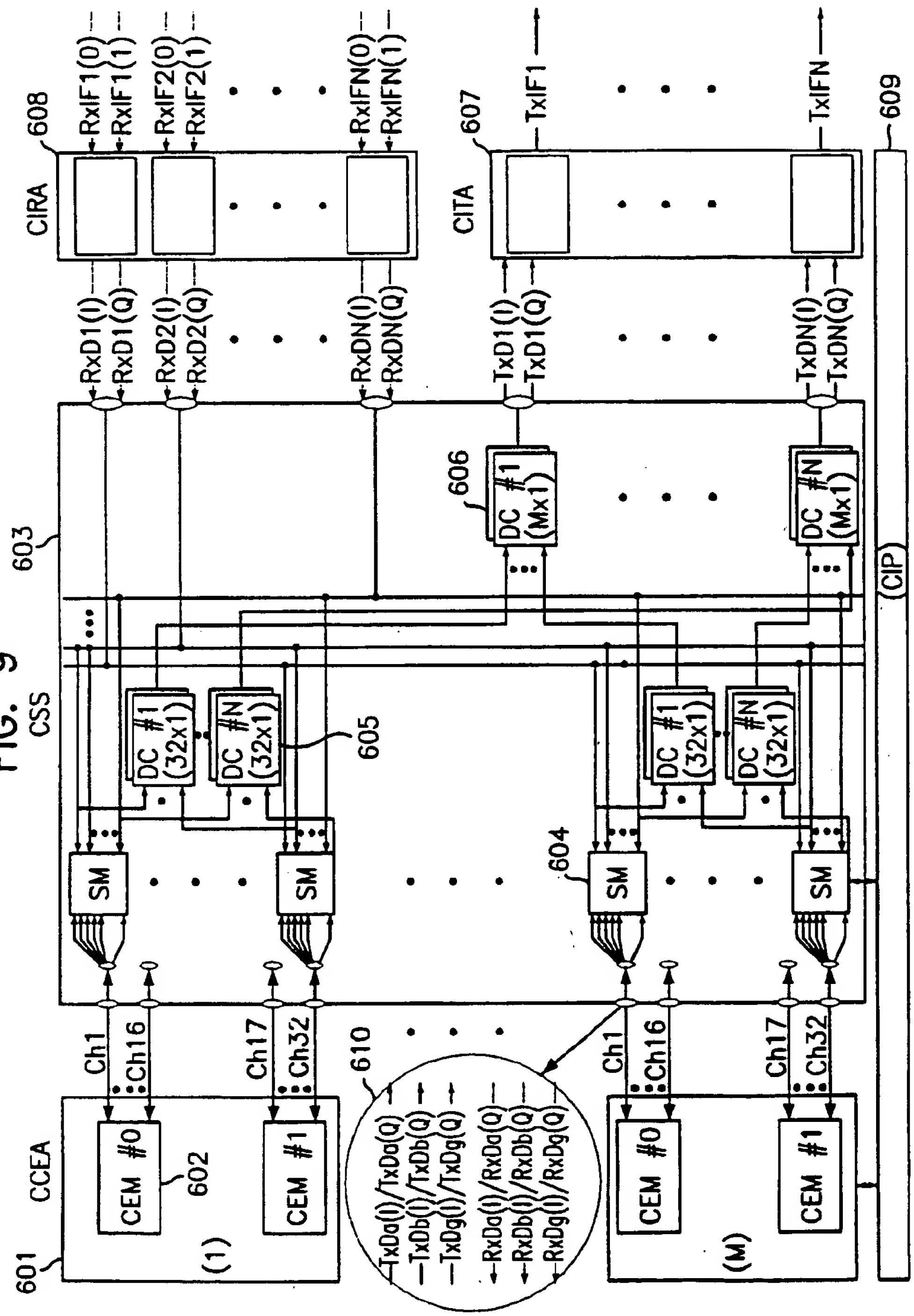
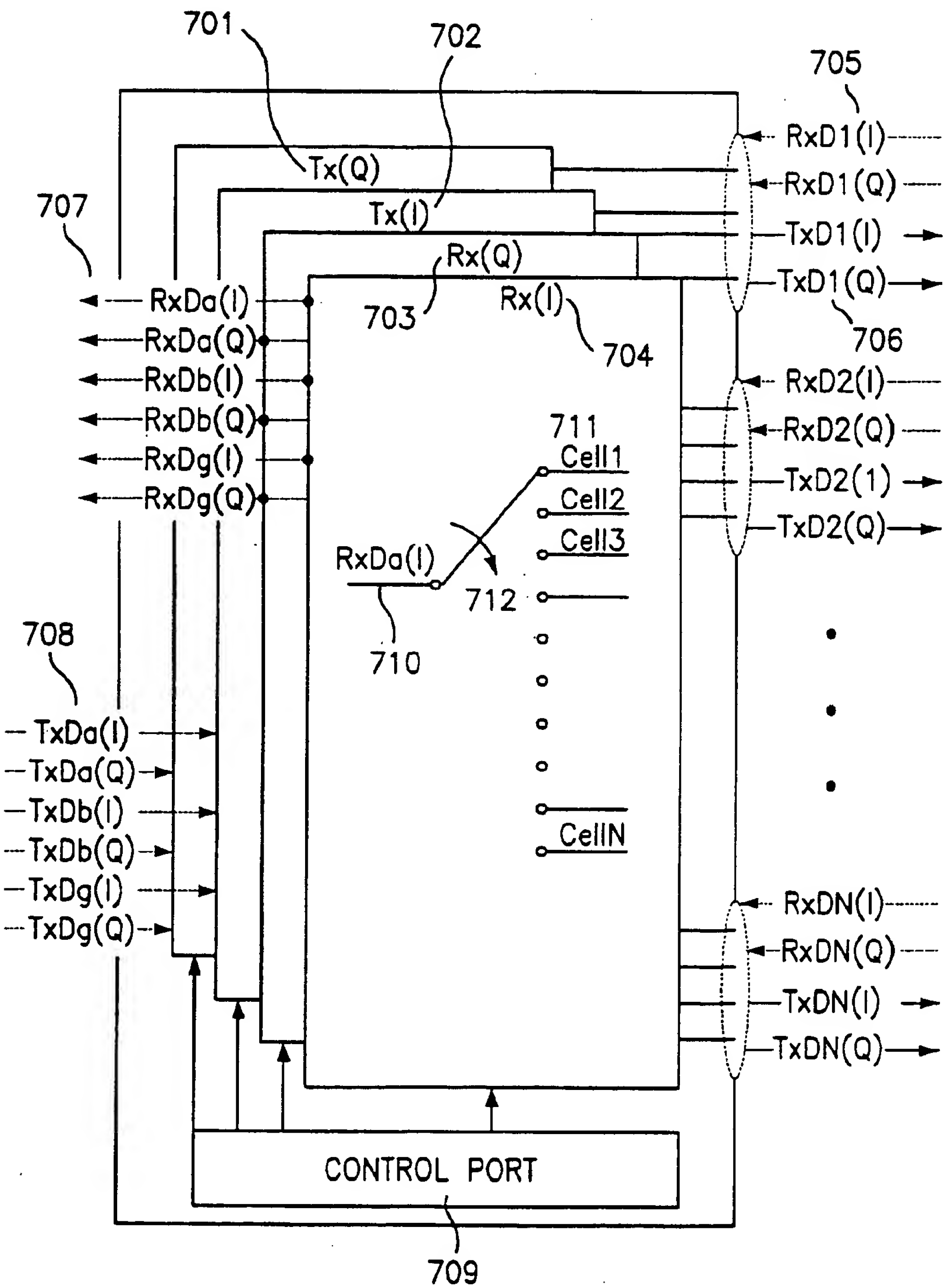

CCEA
601
CEM #0
602
CEM #1
(1)
CEM #0
CEM #1
(M)
Ch1
Ch16
Ch17
Ch32
610
TxDa(I)/TxDa(Q)
TxDb(I)/TxDb(Q)
TxDg(I)/TxDg(Q)
RxDa(I)/RxDa(Q)
RxDb(I)/RxDb(Q)
RxDg(I)/RxDg(Q)
CSS
603
SM
604
DC #1 (32x1)
DC #N (32x1)
605
DC #1 (Mx1)
DC #N (Mx1)
606
RxD1(I)
RxD1(Q)
RxD2(I)
RxD2(Q)
RxDN(I)
RxDN(Q)
TxD1(I)
TxD1(Q)
TxDN(I)
TxDN(Q)
CIRA
608
RxIF1(0)
RxIF1(1)
RxIF2(0)
RxIF2(1)
RxIFN(0)
RxIFN(1)
CITA
607
TxIF1
TxIFN
(CIP)
609

FIG. 10



701
702
705
Tx(Q)
Tx(I)
Rx(Q)
Rx(I)
707
703
704
706
RxD1(I)
RxD1(Q)
TxD1(I)
TxD1(Q)
RxDa(I)
RxDa(Q)
RxDb(I)
RxDb(Q)
RxDg(I)
RxDg(Q)
RxD2(I)
RxD2(Q)
TxD2(1)
TxD2(Q)
711
Cell1
Cell2
Cell3
RxDa(I)
712
710
708
TxDa(I)
TxDa(Q)
TxDb(I)
TxDb(Q)
TxDg(I)
TxDg(Q)
CellN
RxDN(I)
RxDN(Q)
TxDN(I)
TxDN(Q)
CONTROL PORT
709

MICROCELLULAR MOBILE COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates to a microcellular mobile communication system using a Code Division Multiple Access (CDMA) scheme, more particularly the microcellular mobile communication system that provides subscribers with the high-speed mobile communication service more stably by providing the mobile communication service based on a microcell of a radius of several hundred meters, and improves frequency utility efficiency.

The microcellular mobile communication system may extend the life span of a mobile station because a cell radius is small, and is interesting as a structure to which a variety of services (i.e. data and image) are applicable. This microcellular mobile communication system needs a large number of base stations, which will increase the cost of initial facility investment and maintenance. A Base Station Transceiver System (BTS), in the conventional CDMA cellular mobile communication system, is connected with other equipments through E1/T1 or high-speed digital subscriber lines.

Accordingly, the BTS comprises a digital unit including the CDMA Channel Element Assembly (CCEA) for modulating and demodulating the signal of the CDMA scheme, a control processor including a Radio Frequency (RF) signal processing unit, a Base Station Controller (BSC) interface and an operation management interface, and the Global Positioning System (GPS) for synchronization between base stations and so on.

Such a BTS is not appropriate for a mobile communication system composed of a microcell type when taking weight or volume into account. Of course, there is an outdoor BTS of a small capacity structure, but it is difficult to install the BTS appropriate for various RF environments of metropolitan, in which it is needed, every several hundred meters and to extend capacity.

To solve the problems and the shadow areas, an antenna technique using the optical or the separate antenna has been used. However this technique, which transmits only an RF signal from the conventional BTS to a remote antenna through a coaxial cable or an optical fiber, is not appropriate for the mobile communication system of a large scale of microcell type in the future due to a synchronous problem between the conventional BTS and its antenna. That is, these can not perform various functions, needed for the microcell environment, which extend new cells, in order to increase the subscriber capacity, manage resources while maintaining the conventional service, or process a softer handover in more than three cells.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide a microcelluar mobile communication system that can perform various functions such as a centralized management of resources, a capacity increase, a Base Station Transceiver System (BTS) miniaturization, a synchronization between micro base stations, a dynamic resource management, a softer handover between cells, a grouping and ungrouping of base stations in accordance with a traffic distribution.

To achieve the above object, the present invention comprises a GPS receiver for generating a timing information and a reference clock signal to maintain synchronization of a system and a network; a micro base station controller for interfacing with a base station controller, performing a spreading modulation and demodulation, combining signals through a switching operation for dynamic channel allocation between cells and softer handover process, and up-converting the combined signal into at intermediate frequency so that said micro base station controller outputs the up-converted signal with a cable frequency if said micro base station controller transmits a signal to a plurality of micro base stations, and conversely down-converting a received cable frequency into the intermediate frequency so that said micro base station controller transmits a packetized message to said base station controller if said micro base station controller receives a signal from said plurality of micro base stations; a transferring means connected between said GPS receiver and said micro base station controller, for transferring the cable frequency signal in respond to a control signal; and said plurality of micro base stations for transmitting and receiving the cable frequency signal to and from said micro base station controller, respectively, through said transferring means, and for transmitting and receiving a radio frequency signal to and from a mobile station, respectively.

The present invention is divided into a digital hardware and an RF transceiver, the digital hardware and the RF transceiver are connected through optical fibers or hybrid fiber coaxial networks based on the Subcarrier Multiplexing (SCM) technique. The SCM means a transmission scheme that carries information on different frequencies from each other electrically in the transmission stage, combines the carried information, electrical-to-optical converts and transmits it through optical fibers, and optical-to-electrical converts and then recovers to an original signal through a band pass filtering.

The microcellular mobile communication of the present invention comprises a micro Base Station Controller (mBSC), which may manage resources in the center and supports a plurality of microcells, a Hybrid Fiber Radio (HFR) network based on the SCM technique and a plurality of micro Base Stations (mBSs) connected to the mBSC. Here the HFR, as a hybrid technique of the broad band nature of wire (optical fiber) and the mobility of radio, means that it transmits a Radio Frequency (RF) or an Intermediate Frequency (IF) through the optical fiber.

The micro Base Station (mBS) proposed in this invention, is installed within each microcell as an equipment only having an HFR network module, a simple control signal processor, a frequency up/down converter, an amplifier, a filter, a power source and so on. The mBSs are connected with the MBSC through the optical fiber or the hybrid fiber coaxial network. The MBSC performing the centralized control of the mBS comprises the digital hardware of the conventional Base Station Transceiver System (BTS), a Code Stream Switch (CSS) being capable of a dynamic resource allocation and the softer handover, an HFR network management module, the HFR network interface module and so on.

In addition, the mBSC performs the centralized-management of the mBS through the CSS, and minimizes an initial investment cost for constructing a microcell mobile communication system by allocating dynamically an inter-cell communication channel, and allows a cell design satisfying an optimum capacity. That is, the present invention as compared with the distributed control network of the conventional base station, permits the centralized control network, the dynamic channel allocation, and the base

station grouping operation, and may process a handover between base stations with the softer handover.

Referring to a forward link, the mBSC converts a signal to be transmitted to each mBS into a cable frequency signal and then transmits the cable frequency signal through the HFR network. The mBS receives the cable frequency signal and then transmits the RF through an antenna after up-converting the cable frequency signal into the RF for personal communications system. On the other hand, the RF received from a mobile station is received in the mBS and then transmitted to the mBSC through a reverse link.

In particular, the present invention installs a GPS receiver in the mBSC without installing additionally the GPS receiver in the mBS, transmits a reference clock signal from the GPS receiver through the HFR network, and maintains the synchronization between mBSs. Thus the mBS installation cost is reduced, and the cell design may be applied to an indoor, a tunnel and so on that it is difficult for a GPS antenna to be installed. The communication system and network in accordance with the present invention interface with other communication network and are designed so that various radio communication services may be accommodated.

BRIEF DESCRIPTION OF THE DRAWINGS

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 shows schematically an overall construction of a microcellular mobile system for a personal communication according to the present invention.

FIG. 2 shows a connection structure between an mBSC and an for explaining an operation of a forward link function according to the present invention.

FIGS. 3A and 3B show an exemplary embodiment applying offset to pilot PN code according to the present invention.

FIG. 4 is a block diagram of an mBS transmitter according to the present invention.

FIG. 5A shows a distribution of a forward cable frequency.

FIG. 5B shows an exemplary embodiment of a method of allocating a forward cable frequency.

FIG. 6 shows a connection structure between an mBSC and an mBS for explaining an operation of a reverse link function according to the present invention.

FIG. 7 is a block diagram of an mBS receiver according to the present invention.

FIG. 8A shows a distribution of a reverse cable frequency.

FIG. 8B shows an exemplary embodiment of a method of allocating a reverse cable frequency.

FIG. 9 is a block diagram of an MBSC according to the present invention.

FIG. 10 shows a detailed construction of a switching module within a code stream switch according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Preferred embodiments of the present invention will now be described in detail, with reference to the accompanying drawings.

FIG. 1 shows schematically an overall construction of a microcellular mobile system for a personal communication according to the present invention.

In the present invention the micro Base Station (mBS) **102** comprises a radio frequency (RF) front end, an HFR network interface module and so on which were comprised in the conventional Base Station Transceiver System (BTS). The micro Base Station Controller (mBSC) **101** comprises a part corresponding to a digital module, a control part and so on so that the present invention can perform a centralized control management and a dynamic channel allocation. The mBSC **101** and the mBS **102** are connected through the HFR network **103**. A forward link refers to a direction from the mBSC **101** to the mBS **102** and a reverse link does a direction from the mBS **102** to the mBSC **101**. A signal to be transmitted through the HFR network **103** is the signal using a Subcarrier Multiplexing (SCM) scheme and a Wavelength Division Multiplexing (WDM) scheme. The mBSC **101** is connected with the conventional base station controller through a digital connection of E1/T1, HDSL and so on and a signal connection of an interprocessor communication. In the case that a high-level communication network becomes developed into other network, for example, the Asynchronous Transfer Mode (ATM) network **106**, the present invention's mBSC **101** can be connected with the ATM network **106** by only changing the high-level communication network interface module of the mBSC **101**. Although the high-level communication network becomes developed into an intelligent network and an ATM network, the HFR network **103** and the mBS **102** as well as the mBSC **101** may be applied to the intelligent network and the ATM network.

The synchronization between the mBSs **102** is adjusted through the GPS receiver **104** connected to the mBSC **101**, and a reference clock signal is transmitted to the mBS **102** in order to adjust the synchronization between the mBSs **102**.

In the future, the HFR network **103** connected with the HFR network node **107** through the optical fiber may be developed into a form of the public switched telephone network and utilized as an access network of various services such as the wireless/wire cable television and so on.

That is, the microcellular mobile communication system in accordance with the present invention may support efficiently the personal communications service (PCS) of the CDMA scheme, and may adapt superiorly to the development of the high-level communication network, and has a structure that it may support various radio communication services with a form of the HFR public switched telephone network in the future.

And, the present invention is not limited to the personal communications service.

FIG. 2 shows a connection structure between the mBSC and the mBS for explaining an operation of a forward link function according to the present invention.

The Personal Communications Service (PCS) module **201** within the mBSC performs a function corresponding to the digital unit of the conventional Base Station Transceiver System (BTS). The BTS Control Processor (BCP) **206**, as the prior art, comprises a module for interfacing with the conventional base station controller. In addition, the BCP **206** controls the Channel Interface Processor (CIP) **205**, and the CIP **205** controls the CDMA Channel Element Assembly (CCEA) **202** and the Code Stream Switch (CSS) **203**.

In the present invention, the BCP **206** further includes a function for communication with the CIP **205** and a function for interfacing with the HFR network controller **208** in order to control the CSS **203**. Also, the CIP **205** further includes the CSS controlling function for a dynamic resource management and a softer handover between cells.

The CCEA 202 as the prior art performs spread modulation/demodulation functions according to the CDMA scheme. In the present invention, each channel of the CCEA 202 outputs I, Q signals by α, β, γ sectors to the CSS 203.

The CSS 203 performs a function for mapping a three-sector structure to a plurality of microcells, as a structure proposed in the present invention, so that the dynamic channel allocation and the softer handover between cells can be made. The CSS 203 switches appropriately signals received from the CCEA 202 according to the control of the CIP 205 and then combines digital signals received by each of microcells. Such signals are up-converted into the CDMA IF 4.95 MHz through QPSK modulation in the CDMA IF Transmission Assembly (CITA) 204.

The Transceiver block (XCVB) 207 means a network interface module signal, and its function is to convert the output signal of each CITA 204 into a cable frequency by microcells.

The cable frequency combiner 211 combines the output signals of the XCVB 207, a forward control signal for the HFR network management such as the mBSs 216, 221 and 225 maintenance/management and so on, and a reference clock signal in the frequency domain. Such combined electrical signals are converted into the optical frequency λ_1 through the electrical-to-optical converter (E/O). That is, they are transmitted by the SCM scheme.

Referring to FIG. 2, the optical node or optical splitter 214 may be interfaced with HFC network. Where the reference numeral 214 refers to an optical splitter, the reference numeral 215 refers to a structure of star-shaped optical fiber network, and where the reference numeral 214 refers to optical node, the reference numeral 215 refers to a structure of coaxial network. Consequently, the micro base station 216 up-converts a message conveyed on the cable frequency transmitted from the XCVB 207, into the RF, and transmits the up-converted message to a mobile station.

The HFR network controller 208 controls the operation/management of HFR network including the mBS, the grouping/ungrouping of the mBSs, a power source, a plurality of Frequency Allocation (FA) transmissions, the RF change and so on, wherein the HFR network controller 208 controls each mBS by a polling scheme and transmits a forward control channel signal to each mBS, after generating it through the control signal generator 209.

On the other hand, the HFR network controller 208 is connected to a HFR network management system (NMS).

The GPS receiver 212, as the prior art, generates reference clock signals and timing information necessary to each module to maintain the system and network synchronization. In the present invention the reference clock signals are transmitted to each mBS through the cable frequency combiner 211, comprising the GPS receiver 212 to mBS, without installing the GPS receiver every mBS for synchronization between mBSs.

That is, the reference clock signals (for example, 10 MHz) generated from the GPS receiver 212 of mBSC, are transmitted to the mBS through the HFR network for the frequency coherence between mBSs.

The microcellular mobile communication system in the accordance with present invention as described above may be connected with the Wireless Local Loop (WLL) service module 217 for providing a WLL service, and the service module 222 for providing the third generation mobile communication service. That is, the WLL service module 217 up-converts the RF into the cable frequency appropriate to a service and then provides the channel frequency combiner 211 of the present invention with the signals converted by the additional IF converter 218, or converts electrical signals into optical signals using the additional electrical-to-optical converter 219, and then provides the optical splitter or optical node 214 with the converted signals through the optical wavelength coupler (not shown) included in the path 220. Similarly, the third generation mobile communication service module 222 up-converts the RF into the cable frequency appropriate to a service and then provides the channel frequency combiner 211 of the present invention with the signals converted by the additional IF converter 223, or provides the optical wavelength coupler of the path 220 with the RF through the additional electrical-to-optical converter 224. The optical splitter or optical node 214 is connected to the mBSs 221 and 225 for providing these services.

Here, where the demand of each service is great, a wavelength Division Multiplexing (WDM) scheme may be applicable to a service since a broad band spectrum is possible. The electrical-to-optical converters 219 and 224 have different wavelengths λ_2 and λ_3 from the electrical-to-optical converter 213 and the wavelengths λ_2 and λ_3 may be transmitted to each mBS through the optical wavelength coupler of the path 220.

The wavelengths λ_2 and λ_3 are selected in the mBSs 221 and 225, respectively as appropriate to the demand according to optical wavelength and then transmitted by the desired radio frequency band.

The present invention applies for each cell offset values of Pseudo Noise (PN) codes of different pilot channels, and then classifies each cell. For that, at the installation time the microcellular mobile communication system measures or calculates the transfer delay time of signal between the mBSC and the mBS, and applies a store and forward scheme in the mBSC depending upon this transfer delay time, so that the mBSC transmits a pilot message to the mBS while adjusting a timing to each mBS. This procedure is illustrated in FIGS. 3A and 3B in detail.

FIGS. 3A and 3B show an exemplary embodiment applying offset to pilot PN code according to the present invention.

An mBSC module applies an offset value to a delay time value taking the delay time from the mBSC to antennas of every mBS into account. That is, when the mBSC module measures the transfer delay time of HFR network to each mBS using an Optical Time Domain Reflectometer (OTDR) 226 as shown in FIGS. 3A, and finds the transfer delay time of the mBS itself to set a storage time on the basis of GPS time (even second) 227 (FIG. 3B), a message is transmitted from the antenna of each mBS according to pilot pseudo noise code (Point-PN) 228 (FIG. 3B). Such a timing adjustment may be implemented in the CCEA or the CITA within the mBSC.

FIG. 4 is a block diagram of an mBS transmitter according to the present invention.

The optical signals transmitted through the optical fiber link 301 are converted into the electrical signals of cable frequency by the optical-to-electrical converter 302. The signals are converted into radio frequency band by the variable up-converter 305.

Reference clock signals (for example, 10 MHz) are provided to the variable up-converter 305 after being filtered by the Phase Locked Loop (PLL) filter 308 and used as reference frequency for up-converting electrical signals. This reference frequency assures the coherence between mBSs.

Forward control channel signals are decoded in the control signal processor 309 and used to perform the

controlling, maintaining and managing of the mBS. The band pass filter **306** removes unnecessary spurious components and outer band components, and the power amplifier **307** is an amplifier for transmitting a proper power through an antenna. Here an automatic gain control (AGC) function is added to the power amplifier **307** to control the link gain of HFR network and a transmission output. Then, of course the power amplifier **307** receives the control commands of the control signal processor **309**.

Where the reference numeral **214** in FIG. **2** refers to an optical node, and in other words where Hybrid Fiber Coaxial (HFC) network is used, the optical node **214** receives signals through the coaxial cable **303**. Taking the extended distance of the optical node and the mBS into account, a line amplifier may be included in the coaxial cable **303**.

Cable signals, transmitted from the optical node **214** to each mBS through the coaxial cable **303**, are inputted to the Low Noise Amplifier (LNA) **304**, and then the signals are processed in a scheme of using the optical fibers.

Where transmitting signals using the wavelength Division Multiplexing scheme, an optical wavelength coupler may be inserted between the optical fiber **301** and the optical-to-electrical converter **302**, and extracts only the desired optical wavelength signals.

FIG. **5A** shows a procedure of allocating forward cable frequency.

The reference numeral **310** is a reference clock signal of Continuous Wave (CW) for assuring the network coherence, and the reference numeral **311** refers to a signal carrying the forward control channel information, wherein the control channel information includes several parameters, the up-convecting range of cable frequency, the power control information and so on. The forward control channel is transferred on a polling scheme .in the mBSC, and a data format includes mBS ID, command, data field, check sum and so on.

The reference numeral **312** represents a spectrum distribution of forward cable frequency for service, and the 2n number of signal spectrums where using 2FA as for the n number of microcells. IF_{f11} and IF_{f21} are transmitted on the radio frequency **317** like the cells Nos. **1** and **2**, but have offset values of PN codes different from each other. IF_{f11} and IF_{f21} mean signals toward the same cell No. **1**, and are transmitted on different radio frequencies (2FA of the reference numeral **317**).

Any mBS performs the frequency up-converting as in the reference numeral **313** in order to form the microcell No. **1** and adjusts the frequency up-converting as in the reference numeral **314** in order to form the microcell No. **2**. In the same way, the microcell No. n where n is a natural number may be formed. If necessary, each of mBSs may up-convert microcell frequencies for the same number, and at this time it is called "grouped". The way of grouping may improve the quality of service, and reduce greatly the facility investment in little traffic area by processing the dynamic resource allocation in cells.

The IF signals **315** and **316** may be additionally allocated for the WLL service and the third generation mobile communication service, and have extensity for various services such as Local Multipoint Distribution Services (LMDS) and so on. On the other hand, when transmitting signals on the WDM scheme, it is unnecessary for the frequencies **315** and **316** to be distinguished from the frequency **312**.

FIG. **5B** shows an exemplary embodiment of detailed allocation associated with the spectrum of forward cable frequency from FIG. **5A**.

In FIG. **5B**, the reference numeral **321** represents the allocation bandwidth, 6 MHz, of cable frequency spectrum per mBS, and the mBS may be extended up to 3FA. The reference numeral **318** refers to the cable frequency bandwidth (2 MHz) occupied when using 1FA (1.25 MHz), and the frequencies **319** and **320** are for 2FA and 3FA extensions. For example, when the number of microcells is eight, the spectrum distribution occupies 48 MHz as in the reference numeral **322**.

FIG. **6** shows a connection structure between an mBS controller and an mBS for explaining the operation of a reverse link function according to the present invention.

A PCS receive module **401** within the mBSC receives the PCS signals transmitted through the HFR network, and functionally performs the receive function of the conventional digital unit. The BTS control Processor (BCP) **402**, as shown in FIG. **2**, is coupled to the conventional Base Station Controller (BSC) using the BSC and the inter processor communication, The BCP **402** controls the MBSC and an interface with the conventional BSC. The BCP **402** in the present invention is connected with the CIP **403** to control the Code Stream Switch (CSS) **405** and with the HFR network controller **408** to maintain and to manage the HFR network of reverse link. The HFR Network Management System (NMS) **410** is an outside monitoring terminal that has the function of Graphic User Interface such as command input and so on to an operator terminal.

The mBS **415** receives RF signals from personal station, down-converts the signals into the allocated cable frequencies, and then transmits them to the PCS receive module **401** of the mBSC through the link **414** of HFR network interface module.

The link **414**, which connects the mBS with the optical splitter or optical node **413**, may be an optical fiber or a coaxial cable. In the reverse link, the optical splitter is a passive device and has the function of coupling optical signals, so that it combines the optical signals transmitted from each mBS and transmits the combined signals to the mBSC.

Where the link **414** is a coaxial cable, the optical node **413** comprises a cable frequency combiner, an electrical-to-optical conversion module and so on, and it may comprise an amplifier incorporating an equalizer when taking the coaxial cable characteristic into account.

Signals, transmitted from each mBS, are converted into electrical signals by the optical-to-electrical conversion module **412** of the mBSC, the converted signals are filtered by the band pass filter **411** and inputted to the Frequency Conversion Board (XCVB) **407** in order to separate the cable frequency band allocated to each microcell.

The XCVB **407** down-converts signals and makes the signals into IF 4.95 MHz signal for CDMA. And the XCVB **407** measures the Received Signal Strength Indicator (RSSI) and controls a reverse link gain. Output signals of the XCVB **407** are inputted to the CDMA IF Receiving Assembly (CIRA) **406**. The CIRA **406** up-converts CDMA IF (4.95 MHz) signal into I (Inphase) and Q (Quadrature) channel components through QPSK demodulation, performs a digital sampling of analog signals and transmits them to the CSS **405**.

The CSS **405** of the reverse link connects signal transferred from each microcell to appropriate channel devices by the control of the CIP **403** and its detailed block diagram is shown in FIG. **9**.

Received signals inputted from each microcell are despread, deinterleaved and decoded in the CCEA **404** of the

reverse link and then packetized through the BCP **402** to be transferred to BSC.

The control signal extractor **409** extracts polling respond control signals of each mBS through the BPF **411** and then transfers the extracted signals to the HFR network controlling system **410**. Such a content is indicated on the HFR network controller **408**, if necessary. The received control signals contain error message, command implementation results, status monitoring results of each mBS and mBS ID for identifying each mBS.

Each mBS in the reverse link should have an electrical-to-optical converter including an LED and a different physical link from a forward link in consideration of a laser diode or a bandwidth having an optical wavelength spaced by the predetermined interval so as to reduce the beat noise of an optical signal. Where the optical frequencies of the electrical-to-optical converter **213** in the FIG. **2** and the electrical-to-optical converter **507** in the FIG. **7** are set differently from each other, one optical fiber link may be shared in accordance to the wavelength division multiplexing scheme between the forward and reverse links.

Where both the reference numeral **214** in FIG. **2** and the reference numeral **413** in FIG. **6** are optical nodes, the relation between the MBSC and the optical node, may be applicable to the concept as described above. In other words the optical node and the mBS may be connected with different or same coaxial cables. Here where the same coaxial cables are used, the cable frequency shall be allocated differently from each other in the forward and reverse. In particular, each mBS may take remotely the power supply through coaxial cables connected to the optical node.

The invention may operate the WLL service receive module **416** and the third generation mobile communication service receive module **417** within different or same mBSCs. In other words, there are the WLL service receive module **416**, the third mobile communication service receive module **417** or other service modules. Where the SCM transmission capacity of HFR network is sufficient, signals transmitted from the corresponding base stations **421** and **422**, may be transferred to the WLL service receive module **416** and the third generation mobile communication service receive module **417**. Using the wavelength Division Multiplexing scheme, the signals may be transferred through the optical-to-electrical converter **419** and the path **420**. Here the optical-to-electrical converter **419** receives optical wavelength different from the optical-to-electrical converter **412**, and the path **420** includes an optical wavelength coupler (not shown) extracting only a desired wavelength of optical signal.

FIG. 7 is a block diagram of an mBS receiver according to the present invention.

Signals from the mobile station are transferred to the mBS receiver through the diversity antenna and the main receive antenna of the mBS. To assure the signal quality on the fading environment, the two signals from the diversity antenna and the main receive antenna are inputted into the cable frequency combiner **506** of HFR network interface module together with reverse control channel signals generated in the control signal processor **504** via two LNAs **501** different, two band pass filters **502**, and two variable down-converters **503**, which are respectively different from each other.

Signals combined in the cable frequency domain, respectively, are transmitted to optical fibers or coaxial cables through the electrical-to-optical converter **507** or the amplifier **509**.

The variable down-converter **503** down-converts the radio frequency into the cable frequency using the reference clock signal outputted from the PLL filter **505**. The control signal processor **504** specifies the down-converting range of the control signal processor **504**.

Also, the mBS comprises a power supply module, surge arrester, antenna and so on. In Particular, a duplexer is added to the mBS so as to share a transmit/receive antenna.

FIG. **8A** shows the distribution of a reverse cable frequency.

The reference numeral **510** refers to a reverse control channel containing mBS status, power control, module status information and so on. The band of the cable frequency **511** represents a band allocated for PCS, and as for 2FA capacity per each cell when forming the n number of microcells where n is a natural number.

IF_{r11} and IF_{r12} are the cable frequencies in the case that FAs different from each other are applied to the cell No. 1. IF_{r11} and IF_{r12} are the cable frequencies that use the same FA and offset values of pilot PN codes different from each other for the cell No. **1** and the cell No. **2**. The variable down-converter **503** in FIG. **7** can down-convert the filtered RF **514** of receive band into the cable frequencies **515** and **516** for any microcell so that the single operating and the grouping of the mBSs can be accomplished. The reference numeral **512** and **513** respectively, represent the cable frequency distribution of the SCM scheme for the WLL service and the third generation mobile communication service. In the optical wavelength division multiplexing scheme, the cable frequency like PCS may be employed.

FIG. **8B** shows an exemplary embodiment of a method of allocating a reverse cable frequency more detailedly than FIG. **8A**.

Particularly, the FIG. **8B** represents the case that a receive antenna diversity is applied to. The reference numeral **516** and **517** respectively represent received signals through the main receive antenna and the diversity antenna. The reference numeral **519** represents the cable frequency of 2 MHz band allocated to transmit the 1.25 MHz CDMA band signal to the mBSC at 1FA. In order to extend to **2/3**FA, the cable frequency is allocated such as the frequency **520**. After all, where the antenna diversity is applied, the 12 MHz cable frequency bandwidth is assigned to each microcell. The more the number of microcells increases, the more the required cable frequency bandwidth increases.

FIG. **9** is a block diagram of mBSC according to an exemplary embodiment of the present invention and represents the traffic signal flow except for the mBS control signal and the clock/frequency synchronous signal path.

The base station of the conventional scheme has a 3-sector structure, so it is difficult for the base station responsible for at most, three cells to extend to the microcell system.

The characteristic of mBSC structure for overcoming the problem is that the softer handover is possible between a plurality of cells and the dynamic channel allocation is possible by applying the CCS **603**.

One CDMA Channel Element Assembly (CCEA) **601** comprises the two Channel Element Modules **602**, and each channel element module comprises 16 channel elements.

The number of such a CCEA may be extended up to the M (M is a natural number), and in this case the number of channel elements becomes M×32. In the forward link, each channel element receives decoded voice data and control information from the BSC, and outputs I and Q signals for

each of α, β and γ sectors to the corresponding switching module (SM) **604** of the CCS **603**.

These kinds of signals for channels are as shown in the reference numeral **610**.

The switching module **604** switches signals transferred from the channel element module **602** to the given destination cells in accordance with the control of the Channel Interface Processor (CIP) **609**.

I and Q signals toward each destination cell are combined first through the 32×1 digital combiners **605**. The 2N number of the 32×1 digital combiners **605** per one CDMA channel assembly **601** for the N number of cells are required.

The first digital-combined I and Q signals, are combined in each of the M×1 digital combiners **606** secondly. Output I and Q signals of the second combined M×1 digital combiners **607** are inputted to the CDMA IF Transmission Assembly (CITA) **607** transmitting CDMA IF signals. The CDMA IF Transmission Assembly **607** converts the digital signals into the analog signals, combines and up-converts them into IF signals through QPSK modulation. The CDMA IF signals for each of destination cells are inputted into the XCVB **407**, HFR network interface module.

In the case of the reverse link, main signals by cells and diversity signals for each cell which are inputted into the CDMA IF Receive Assembly (CIRA) **608** through the XCVB **407**, HFR network interface module, are down-converted into baseband I and Q signals.

Main signals and diversity signals are converted into digital signals, and multiplexed, and then inputted into the CSS **603**. The signals are inputted into every switching module **604**.

The Channel Interface Processor (CIP) **609** communicates with the BCP and the BSC in order to connect with the required channel elements and the signals, and then controls the switching module **604**. These kinds of detailed signals of the reverse link are shown as in the reference numeral **610**. According to the demand, each channel element can transmit and receive data, so that the channel element modules **602** and the switching module **604** provide the bidirectional communication path.

The mBSC according to the present invention may support a plurality of cells needed for the microcell system, and have the structure of the CSS for conversion between a 3-sector and the N number of cells. Particularly, by utilizing the code stream switch, the dynamic resource management between microcells is possible and the softer handover may be extended up to the N number of cells.

FIG. **10** shows a construction of a switching module within a code stream switch according to the present invention.

A switching module (SM) is an important module of a Code Stream Switch (CSS) within the mBSC. The SM enables the efficient dynamic resource management and the softer handover between cells on the environment of microcells.

The dynamic resource management is a function which may allocate a specific channel element to one of a number of cells if necessary and which is necessary surely since the traffic density is ununiform in accordance with the time and space of microcell environment.

When the mobile station moves to another cell during conversation, the softer handover is the function that may assure the movement between mobile station cells without conversation cutoff. In the general case, the mobile station may pass the overlapping area of three cells at most, among the N number of cells and therefore each channel element shall transmit and receive signals to three cells needed for the mobile station. To support such a function, the switching module within the CSS has a line switch structure that is composed of Single Pole Multi Throw (SPMT) switch matrix.

All the transmit (Tx) and receive (Rx) signals are divided into I and Q signals, and processed. So four 3×N switches are required for the N cells. That is, two 3×N switches **701** and **702** are required for two Tx signals and others **703** and **704** are required for two Rx signals. In the figure, the reference numeral **705** and **706** represent the received and transmitted signals from and to the side of the cell No.1. Here the signals exist respectively for each of cells.

In the figure, the reference numeral **707** represents I and Q received signals of each of three cells corresponding to each of α, β and γ sectors needed for communicating between a specific channel element and a mobile station. The control port **709** controls the selection and connection of three cells among the N number of cells.

For example, if the received signal **711** from the cell No.**1** is connected to the received data **710** by the switch **712**, a specific channel element connected with the received data **710** may perform a function for receiving the specific channel of the cell No.**1** signal. Because each channel element and cell may be connected variably through a switching module, a channel may be allocated dynamically to a specific cell for which traffic is needed.

An exemplary embodiment of softer handover may be explained as follows. The same concept is applied to both forward and reverse paths, so now only the reverse softer handover will be described.

When a mobile station is busy in the cell No.**2**, the channel element connected with the received data **707** processes the traffic channel of the mobile station. Then, the received data (RxDa) **707** is connected with the cell No.**2**.

When the mobile station moves from the cell No.**2** to the cell No.**3**, the handover occurs in the overlapping area. Then, the received data (RxDa) **707** is connected to the cell No.**2** and the received data (RxDb) **707** is connected to the cell No.**3**.

If the mobile station has moved completely into the cell No.**3**, the received data (RxDa) is connected to the cell No.**3**. Therefore, the softer handover is implemented. The softer handover means that the handover is processed without cutoff of the connection between a channel element and a mobile station. When the mobile station moves to another cell, the softer handover is processed in the same way.

As described above, the present invention has the following effects.

1) The present invention may increase the subscriber capacity, provide the high reliable service, extend the battery life of a personal station by inducing low power communication and assure the radio channel capacity so that the radio multimedia service can be accomplished in the future, by maximizing the utility efficiency of radio frequency resource through cell miniaturization.

2) As a base station equipment is minimized, the present invention may reduce time and cost required to install a large number of base stations under picocell or microcell environment of a cell radius of several decades to several hundred meters by applying HFR technique and separating CDMA digital hardware and radio frequency transceiver unit. In addition, since the base station equipment is small, additional base station selection is unnecessary, and the base

station installation may be facilitated in the metropolitan radio environment. And the present invention may reduce the power consumption of micro base station equipment and improve reliability of the base station.

3) The present invention may transmit a number of carriers through one transmission link by applying the SCM and WDM transmission techniques.

4) The present invention may distribute efficiently resources through the dynamic resource management under a complicated metropolitan environment of which traffic density is quite different from each other in accordance with areas and times.

5) The system according to present invention may be installed efficiently to an indoor, a building underground, an underground tunnel as well as an outdoor, and may compose the single cell also in the indoor, and can convert readily to the structure of a separated antenna of single cell.

6) The installation of new base station channel element is made on the center, so that extension of system capacity may be easily implemented, support a high-speed data service including voice service by the wideband of micro base station and reduce the cost of maintenance and initial facility investment.

7) The present invention may change only the interface module of micro base station controller, thus accommodating the development of high-level communication network without changing each base station equipment. And the present invention adds a necessary application service module and provides services through the same HFR network that may be provided as a type of PSTN in the future.

8) The present invention can provide the reliable service through the centralized management since the required error reporting and the simple control can be made.

9) The present invention may reduce the cost of initial facility investment by establishing HFR network using the conventional CATV cable network without installing additionally optical cables to main node. The HFR network as well as the optical node or optical splitter may be implemented through the optical cable network establishment or the coaxial cable network of conventional HFC.

10) The present invention may support more than three microcells.

11) The present invention processes the handover between microcells as in the softer handover between the conventional sectors, and may improve the speech quality.

12) The present invention may be converted to the microcell system in the subscriber area of high density without changing a high-level network of a base station controller by having compatibility with the conventional BCP.

13) The present invention applies the synchronous scheme between micro base stations and so provides the reliable service. In particular, synchronization may be obtained by the store & forward scheme and transmission of the reference clock signal without installation of GPS to each micro base station.

14) Each micro base station may do grouping and ungrouping depending upon necessity, so the present invention may perform the grouping of service initially and operates like macrocell, distribute the limited resource according to the traffic distribution and operate with the same infra when the demand increases.

Although the preferred embodiments of the invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

What is claimed is:

1. A micro cellular system for use in a wireless communication system based on a Code Division Multiple Access (CDMA) technology, comprising:

a micro base station controller (mBSC) ,connected to abase station controller(BSC), for receiving forward link traffic signals from the BSC, performing a spread modulation with respect to the forward link traffic signals, supporting an inter-cell handoff, combining the spread modulated signals, converting the combined signals into analog signals by using a digital modulation scheme and converting the analog signals into forward link hybrid fiber-radio(HFR) cable frequency signals in a forward link, and for receiving reverse link HFR cable frequency signals, extracting carrier signals bearing reverse link traffic signals from the reverse link HFR cable frequency signals, frequency down converting the carrier signals, converting the frequency down converted signals into reverse link digital signals by using a digital demodulation scheme, performing a spread demodulation with respect to the reverse link digital signals to thereby produce reverse link traffic signals and transmitting the reverse link traffic signals to the BSC in a reverse link;

a plurality of micro base stations, each connected to the mBSC and whole or part of the plurality of the micro base stations being included in a same micro cell, for transferring the HFR cable frequency signals including the forward link and the reverse link HFR cable frequency signals and transmitting/receiving RF (Radio Frequency) signals to/from a multiplicity of mobile stations, wherein each micro base station has one among a laser diode whose optical wavelengths are separated from each other and a light emitting diode; and

a HFR network, connecting the MBSC to the plurality of micro base stations, for converting the forward link HFR cable frequency signals into forward link optical signals, outputting the forward link optical signals via a single optical fiber core connected thereto and distributing the forward link optical signals to each micro base station in the forward link, for combining reverse link optical signals received from each micro base station, the combined reverse link optical signals being transferred via the single fiber core, converting the reverse link optical signals into electrical signals to thereby produce reverse link HFR cable frequency signals and transferring the reverse link HFR cable frequency signals to the mBSC,

wherein the micro cell is distinguished from other micro cells by its forward link and reverse link HFR cable frequency bands and the number of the frequency bands of each of the forward link and the reverse link HFR cable frequency signals ranges from one to the number of the plurality of the micro base stations.

2. The microcellular system of claim **1**, wherein the mBSC includes:

a HFR network controller for generating forward link control channel signals, transmitting the forward link control channel signals to each micro base station, extracting reverse link control channel signals received from each micro base station, performing operation and management of each micro base station and interworking with HFR NMS (Network Management System) based on a GUI (Graphic User Interface),

wherein the operation and management is performed by using a polling scheme.

3. The microcellular system of claim 1 or 2, wherein the HFR network includes:

a frequency combiner for combining the HFR cable frequency signals from each micro base station and the forward link control channel signals from the HFR network controller;

a first E/O (Electrical to Optical) converter for converting output signals from the frequency combiner into the forward link optical signals;

a first O/E (Optical to Electrical) converter for separating the reverse link optical signals from the forward link optical signals by using optical coupling and converting the reverse link optical signals into electrical equivalents;

an optical signal distributing/combining means, connected to the single fiber core by way of at least one optical coupling for bidirectional communication, for distributing the forward link optical signals to each mBSC and combining the reverse link optical signals received from each micro base station via the single fiber core; and

a frequency divider for dividing the output signals from the first O/E converter into a plurality of reverse link HFR cable frequency signals and the reverse link control channel signals, and bandpass filtering the re-verse link HPR cable frequency signals to thereby extracting one or more micro cell designation signals, each designating a micro cell.

4. The microcellular system of claim 3, wherein the optical signal distributing/combining means supports one or both of a passive star network employing no active elements and a HFC (Hybrid Fiber-Coaxial) network employing an optical node to connect the single fiber core to a coaxial cable network.

5. The microcellular system of claim 4, wherein the HFC network has a forward link O/E converter and a reverse link E/O converter in the optical node, wherein each of the forward link O/E converter and a reverse link E/O converter is connected to the corresponding micro base station via one coaxial cable, and a forward link low noise amplifier and a reverse link line amplifier are engaged in the connection.

6. The micro cellular system of claim 3, wherein the optical signal distributing/combining means, in case that it supports both of the WLL service and the IMT-2000 service, combines signals for each service by using a wavelength coupler so that the optical wavelengths are different for each service.

7. The microcellular system of claim 1, further comprising

a Global Positioning System(GPS) receiver for receiving GPS signals and generating timing information and reference clock signals for use in synchronizing the system,

wherein the mBSC evaluates propagation delay time of signals therefrom to antennas connected to the micro base stations, and each micro cell is distinguished by applying a distinct pilot pseudo noise (PN) code offset to each micro cell in consideration for the propagation delay time including a delay time of each micro base station itself.

8. The microcellular system of claim 1, wherein said each mBSC includes:

a local controller for controlling a softer handover between each micro cell, performing a centralized dynamic resources management and controlling operation and management of the mBSC;

a channel switch, under the control of the local controller, for performing switching, combining and dividing to convert a three sector structure into N micro cells, producing the combined signals by switching and combining the spread modulated signals, converting the combined signals into analog signals by using the digital modulation scheme, converting the analog signals into the forward link HFR cable frequency signals and outputting the forward link HFR cable frequency signals to the HFR network in the forward link, for dividing, switching and spread demodulating the reverse link digital signals converted by the digital demodulation scheme, and extracting reverse link HFR cable frequency signals corresponding to each micro cell.

9. The micro cellular system of claim 26, where in the HFR cable frequency signals include:

forward link control channel signals and reverse link control channel signals, each for use in monitoring status of each micro base station and adjusting variables by using ID numbers incorporated therein;

forward link and reverse link HFR cable frequency signals for transferring the carrier signals between the mBSC and the plurality of micro base stations, wherein each of the forward link and the reverse link HFR cable frequency signals has therein the RF signals or IF(Intermediate Frequency) signals.

10. The microcellular system of claim 9, wherein the forward link HFR cable frequency signals further include CW (Continuous Wave) reference frequency signals for frequency coherence of the HFR network and the micro base stations.

11. The microcellular system of claim 10, wherein each micro base station has:

a transmitter for transmitting forward link RF signals to the mobile stations, each mobile station being air-coupled to the micro base stations; and

a receiver for receiving reverse link RF signals from each mobile station;

a reference frequency signal generator for receiving the CW reference frequency signals, receiving the reference frequency signals from the transmitter and reproducing the reference frequency signals;

a forward link RF signal processor, under the control of the micro base station, for receiving the output from the reference frequency signal generator and selecting frequency bands of the forward link HFR cable frequency; and

a reverse link RF signal processor, under the control of the micro base station, for receiving the output from the reference frequency signal generator and selecting frequency bands of the reverse link HFR cable frequency.

12. The microcellular system of claim 9, wherein the HFR cable frequency signals include any one of service carrier signals among WLL (Wireless Local Loop) service carrier signals and IMT-2000 (International Mobile Telecommunications-2000) service carrier signals.

13. The microcellular system of claim 9, wherein the forward link and the reverse link HFR cable frequency signals have transmission bandwidth wider than or equal to the bandwidth of the RF signals.

14. The microcellular system of claim 1, wherein each micro base station includes:

a transmitter for transmitting forward link RF signals to the mobile stations, each mobile station being air-coupled to micro base stations; and

a receiver for receiving reverse link RF signals from each mobile station;

wherein the transmitter has:

a second O/E converter for converting the forward link optical signals transmitted from them BSC via the HFR network into the electrical equivalents;

a first signal distributor for dividing the electrical signals converted at the second O/E converter;

a transmitter base station control processor for extracting the forward link control channel signals from the output from the first signal distributor and monitoring the status of or controlling the micro base station in response to the forward link control channel signals;

a forward link RF signal processor for selecting a designated forward link HFR cable frequency signal band indicated by the transmitter base station control processor, converting the selected band into the forward link RF signals and bandpass filtering the selected band into the forward link RF signals; and

a high power amplifier for amplifying the output from the forward link RF signal processor to an appropriate level to transmit by way of antenna; and

the receiver has:

a low noise amplifier for amplifying signals from the antenna of the micro base station while suppressing noise therein;

a reverse link RF processor for bandpass filtering the output from the low noise amplifier and converting the filtered output into the designated reverse link HFR cable frequency signal band;

receiver micro base station control processor for generating the reverse link control channel signal containing information on the status and control of the micro base station;

a first signal combiner for combining the output from the reverse link RF signal processor and the reverse link control channel signals; and

a second E/O converter for E/O converting the output from the first signal combiner, wherein the second E/O converter has therein as its light source one of a light emitting diode and a laser diode, wherein the laser diode having a plurality of wavelengths, each wavelength corresponding to each micro base station.

15. The microcellular system of claim **14**, wherein the micro base station uses a diversity receiving path in an additional band distinct from the reverse link HFR cable frequency band to thereby support a receiver antenna diversity function.

16. The microcellular system of claim **1**, wherein a part of the plurality of micro base stations are grouped together such that the micro base stations belonging to the part select signals having the same HFR cable frequency signal band, and the grouping is adjustable by an operator.

17. A HFR interface architecture for use in a CDMA-based wireless communication system, transferring signals between a BTS (Base Station Transceiver Subsystem) and a plurality of micro base stations, each micro base station being connected to the BTS and air coupled with a plurality of mobile terminals, wherein forward link electrical signals are transferred from the BTS to the plurality of micro base stations after being converted into forward link optical signals and reverse link electrical signals from each micro base station are collectively transferred to the BTS after being converted into reverse link optical signals therein, each of the signals being used in defining micro cells and/or sectors, the architecture comprising:

a BTS adapter, in a forward link, for receiving output from the BTS, converting the output into forward link HFR cable frequency signals and converting the forward link HFR cable frequency signals into the forward link optical signals, and in a reverse link, for receiving the reverse link optical signals including the reverser link cable frequency signals from the plurality of micro base stations, converting the reverse link optical signals into reverse link HFR cable frequency signals and providing the reverse link HFR cable frequency signals as input signals to the BTS, wherein the number of the forward link and the reverse link HFR cable frequency bands ranges from one to the number of the plurality of the micro base stations;

a plurality of micro base station interface units, each having one among a laser diode whose optical wavelengths are separated from each other and a light emitting diode, for converting the forward link optical signals received from the BTS adapter into the forward link electrical signals in the forward link and for converting the reverse link electrical signals received from the plurality of micro base stations into the reverse link optical signals; and

a cable means for transfers the forward link and the reverse link optical signals between the BTS adapter and the plurality of micro base station interface units via a single fiber core and including therein more than one optical couplers connecting more than one micro base stations.

18. The HFR interface architecture of claim **17**, wherein signals transferred between the BTS and the BTS adapter are RF signals, frequencies of the RF signals is the same as the frequencies of the RF signals used in communicating between the micro base stations and the mobile stations, and the frequencies of the HFR cable frequency signals transferred between the BTS adapter and the micro base station interfacing units has frequency bands are one of the RF signals and IF signals.

19. The HFR interface architecture of claim **17**, wherein the forward link HFR cable frequency signals include carrier signals carrying traffic signals and forward link control channel signals; and the reverse link HFR cable frequency signals include primary signals and the reverse link control channel signals, wherein the carrier signals have the bandwidth wider than or equal to the bandwidth of the RF signals.

20. The HFR interface architecture of claim **19**, wherein the forward link HFR cable frequency signals further include reference frequency signals for frequency coherence of the HFR network and the micro base stations.

21. The HFR interface architecture of claim **19**, wherein the reverse link HFR cable frequency signals further include diversity signals in an additional band distinct from the reverse link HFR cable frequency band to thereby support a receiver antenna diversity function.

* * * * *

US006570856B1

(12) United States Patent
Freeburg et al.

(10) **Patent No.: US 6,570,856 B1**
(45) **Date of Patent: May 27, 2003**

(54) **METHOD OF HANDOFF BETWEEN BASE STATIONS IN A WIRELESS COMMUNICATIONS SYSTEM**

(75) Inventors: **Thomas A. Freeburg**, Arlington Heights, IL (US); **Daniel B. Grossman**, Norwood, MA (US); **Paul Odlyzko**, Arlington Heights, IL (US)

(73) Assignee: **Motorola, Inc.**, Schaumburg, IL (US)

(21) Appl. No.: **09/215,969**

(22) Filed: **Dec. 18, 1998**

Related U.S. Application Data

(62) Division of application No. 08/615,381, filed on Mar. 14, 1996, now Pat. No. 5,940,381.

(51) **Int. Cl.**[7] **H04B 7/00**; H04L 12/28

(52) **U.S. Cl.** **370/310.1**; 370/331

(58) **Field of Search** 370/310.1, 310.2, 370/313, 331, 395.1, 396, 397, 395.2, 395.3; 455/460, 445

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,434,853 A * 7/1995 Hemmady et al. 370/331
5,434,859 A 7/1995 Levardon
5,590,125 A * 12/1996 Acampora et al. 370/397
5,636,215 A * 6/1997 Kubo et al. 370/397
5,638,371 A 6/1997 Raychaudhuri et al.
5,648,969 A 7/1997 Pasternak et al.
5,659,544 A 8/1997 La Porta et al.
5,666,349 A 9/1997 Petri
5,684,791 A * 11/1997 Raychaudhuri et al. .. 370/310.2
5,805,580 A * 9/1998 Vercauteren et al. 370/331
5,875,185 A * 2/1999 Wang et al. 370/331
5,920,817 A * 7/1999 Umeda et al. 370/331
6,081,715 A * 6/2000 La Porta et al. 370/331

FOREIGN PATENT DOCUMENTS

FI	0577322	1/1994
GB	0679042	10/1995
WO	WO94/28645	12/1994
WO	WO95/32594	11/1995

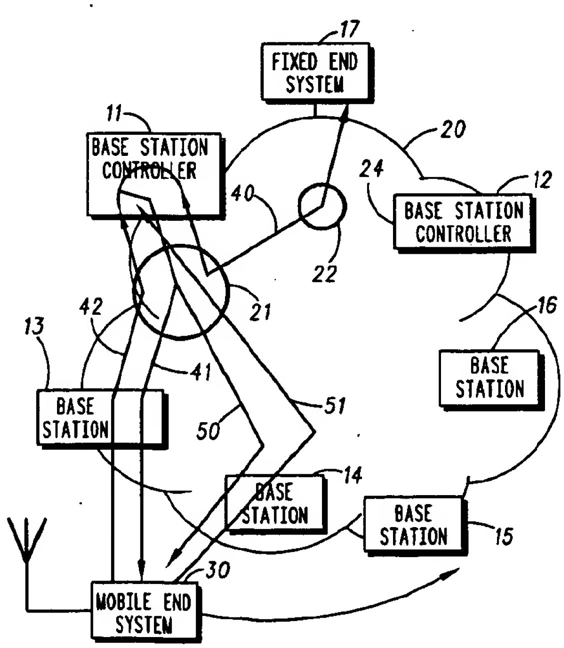
* cited by examiner

Primary Examiner—Chau Nguyen
Assistant Examiner—Andy Lee
(74) *Attorney, Agent, or Firm*—Randall S. Vaas

(57) **ABSTRACT**

A radio communications system (**10**) having a mobile station (**30**) and at least two base stations (**13, 14**). ATM radio channels (**31, 32**) are provided between the remote station and the base stations. Each of the ATM channels supports communication though ATM cells over a common frequency band. When handoff conditions are met for a handoff from the first base station to the second base station, a second virtual path identifier and a second virtual connection identifier are selected for a connection between the second base station and the remote station.

4 Claims, 11 Drawing Sheets



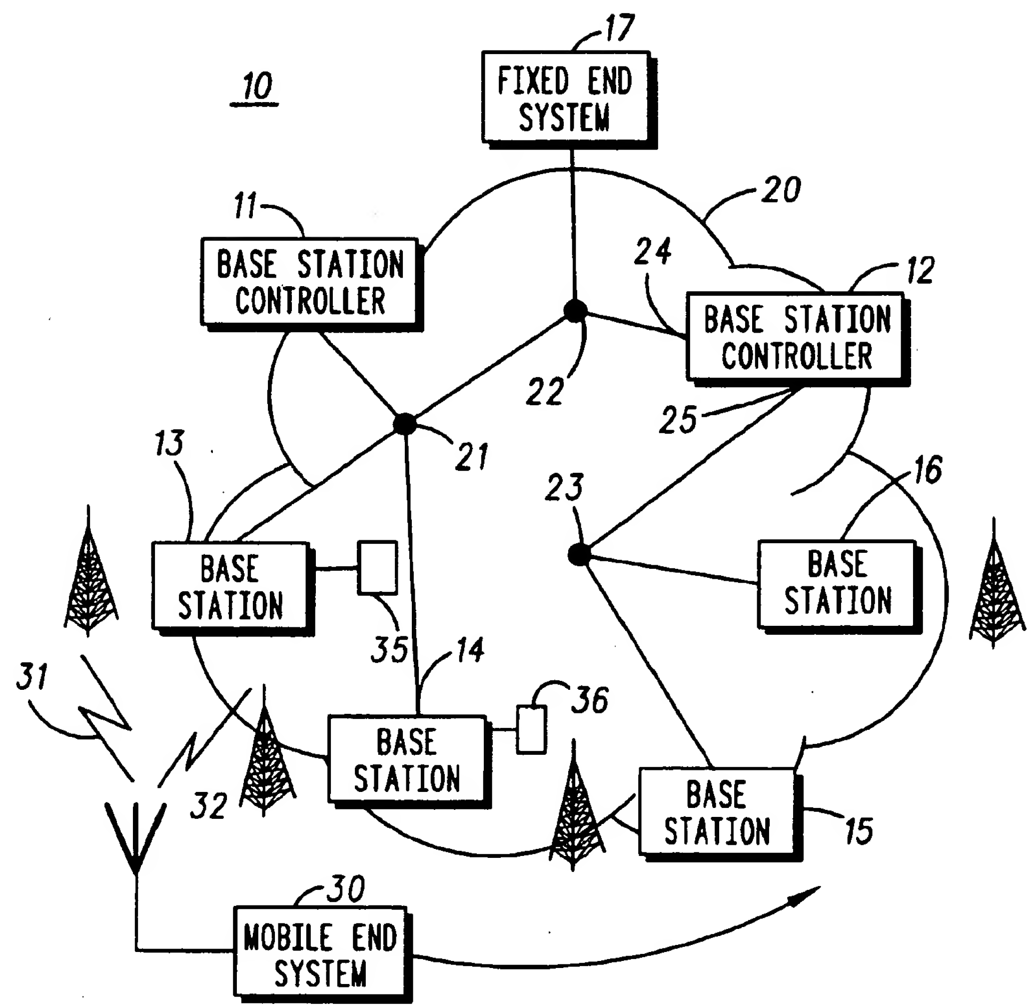

10
17
FIXED END SYSTEM
20
11
BASE STATION CONTROLLER
24
12
BASE STATION CONTROLLER
22
25
13
21
23
16
BASE STATION
BASE STATION
35
14
31
36
BASE STATION
32
BASE STATION
15
30
MOBILE END SYSTEM

FIG.1

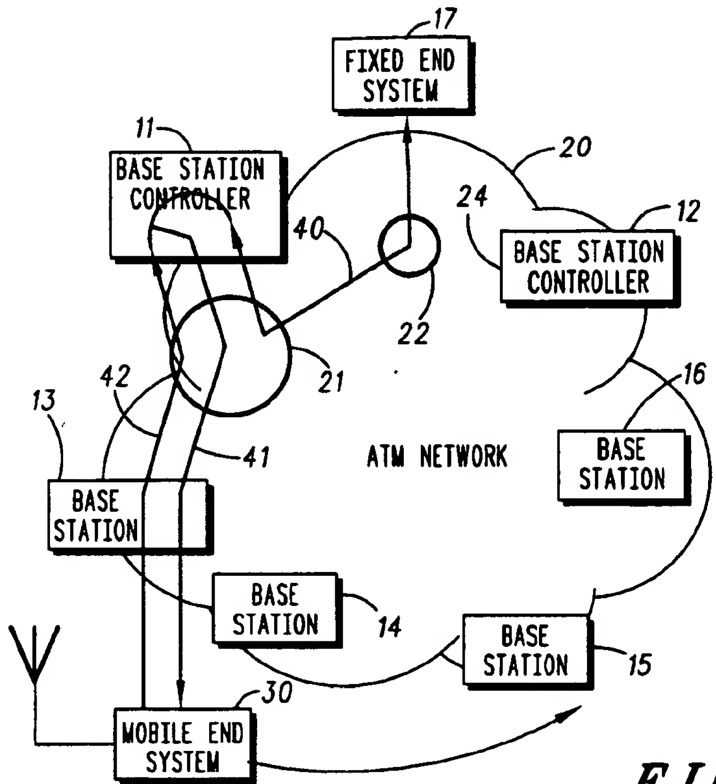

FIXED END SYSTEM
17
11
BASE STATION CONTROLLER
20
24
12
BASE STATION CONTROLLER
40
22
21
16
42
13
41
ATM NETWORK
BASE STATION
BASE STATION
BASE STATION
14
BASE STATION
15
30
MOBILE END SYSTEM

FIG. 2

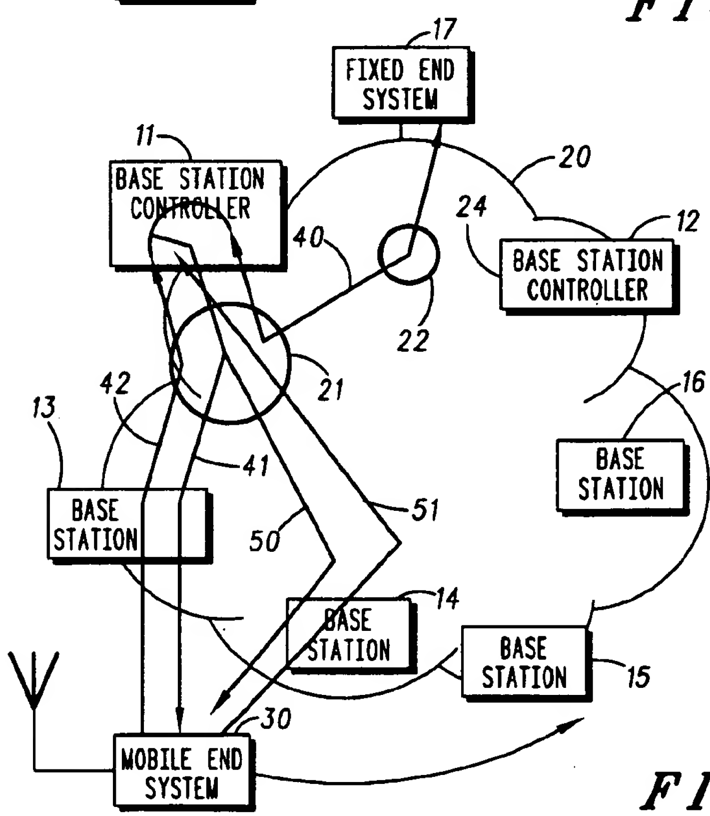

FIXED END SYSTEM
17
11
BASE STATION CONTROLLER
20
24
12
BASE STATION CONTROLLER
40
22
21
16
42
13
41
BASE STATION
BASE STATION
51
50
14
BASE STATION
BASE STATION
15
30
MOBILE END SYSTEM

FIG. 3

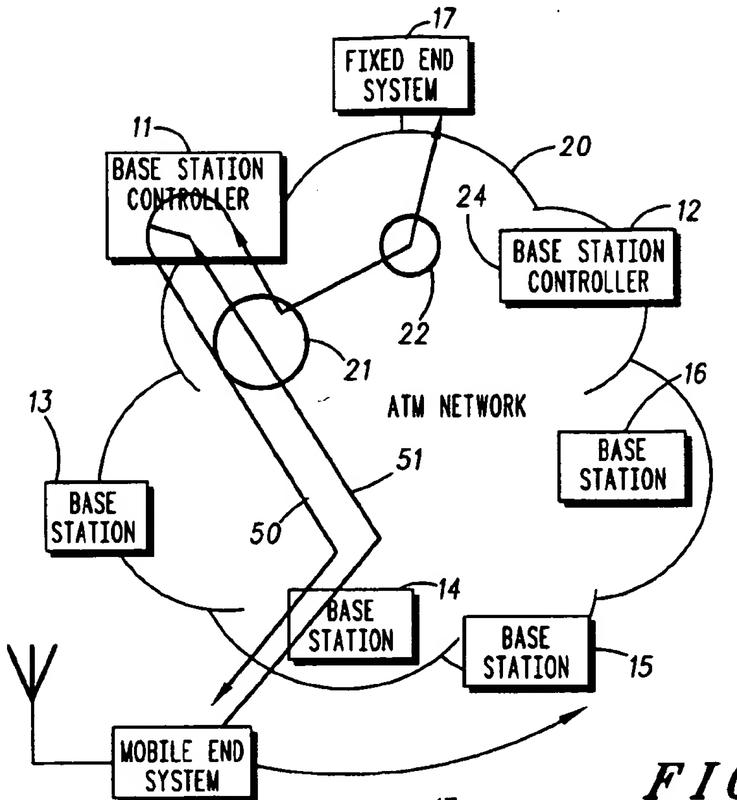

17
FIXED END SYSTEM
11
BASE STATION CONTROLLER
20
24
12
BASE STATION CONTROLLER
22
21
16
ATM NETWORK
13
BASE STATION
51
BASE STATION
50
14
BASE STATION
BASE STATION
15
MOBILE END SYSTEM

FIG.4

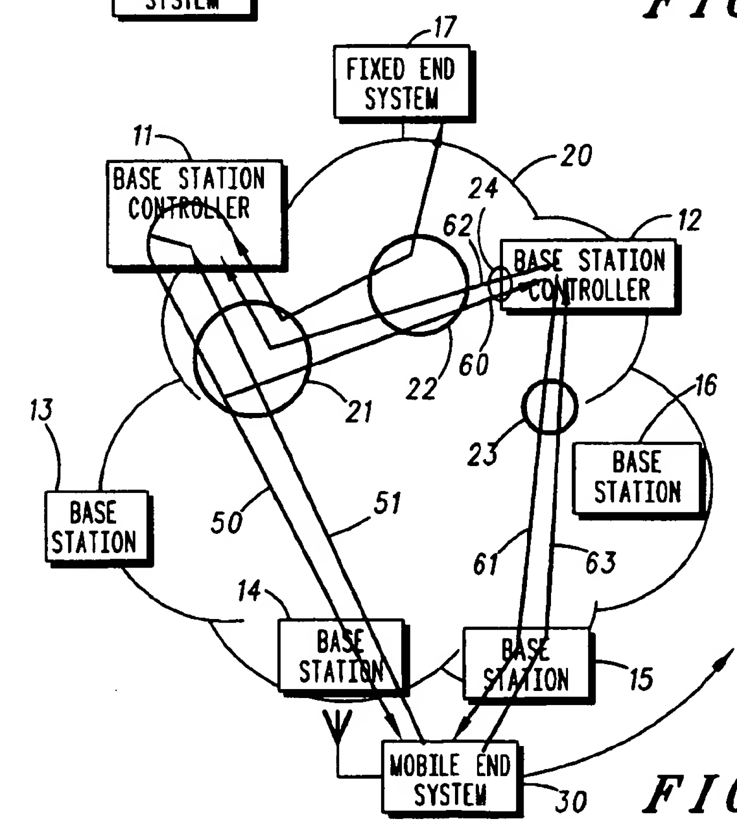

17
FIXED END SYSTEM
11
BASE STATION CONTROLLER
20
24
62
12
BASE STATION CONTROLLER
60
22
21
16
13
23
BASE STATION
BASE STATION
50
51
61
63
14
BASE STATION
BASE STATION
15
MOBILE END SYSTEM
30

FIG.5

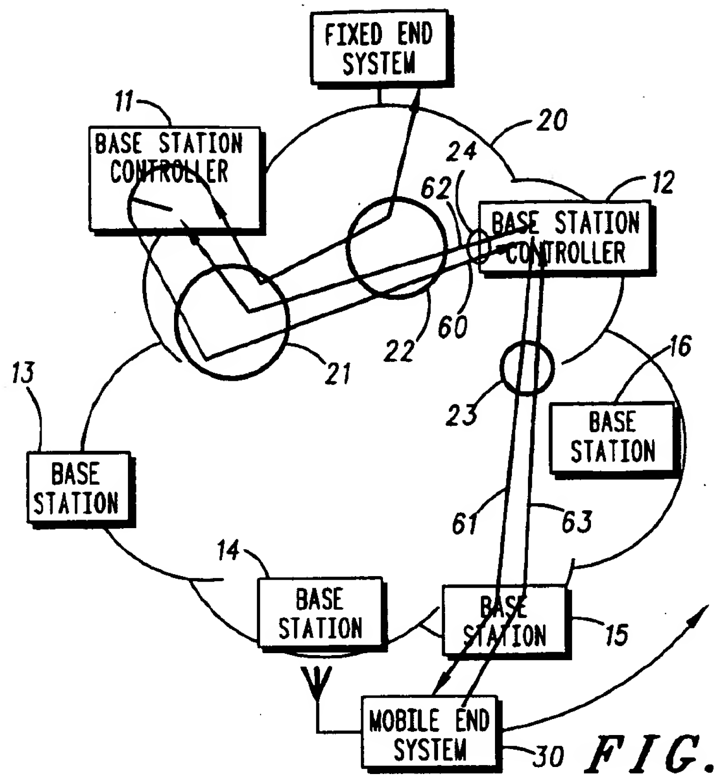
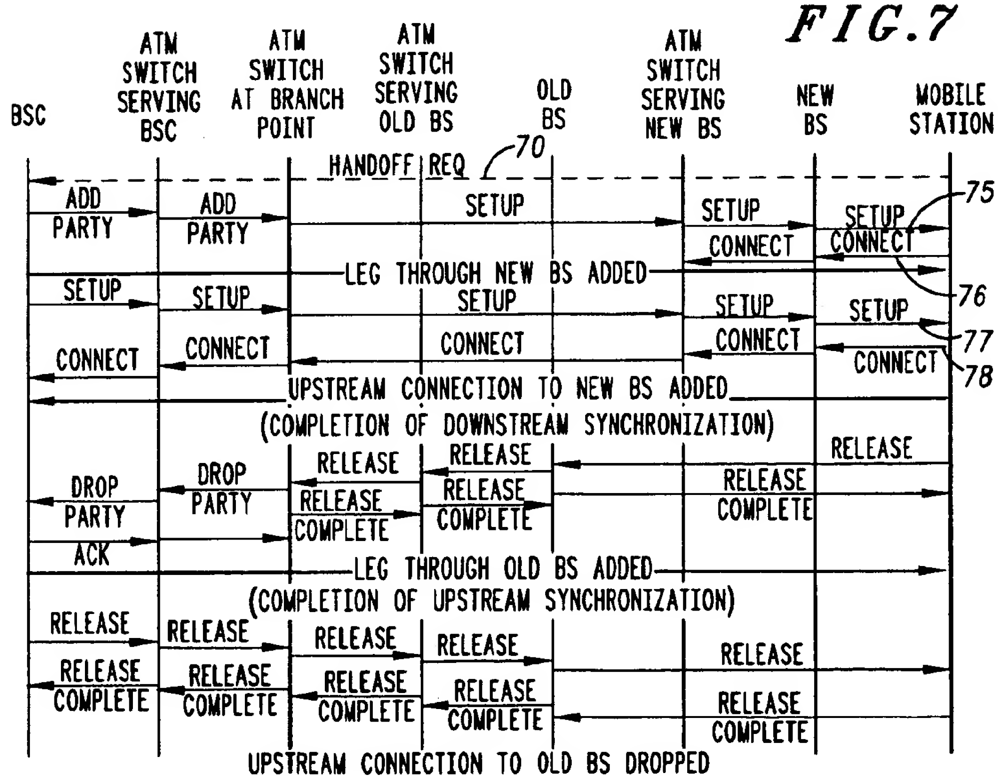

FIXED END SYSTEM
BASE STATION CONTROLLER
BASE STATION CONTROLLER
BASE STATION
BASE STATION
BASE STATION
BASE STATION
MOBILE END SYSTEM
11
12
13
14
15
16
20
21
22
23
24
30
60
61
62
63

FIG.6

FIG.7


BSC
ATM SWITCH SERVING BSC
ATM SWITCH AT BRANCH POINT
ATM SWITCH SERVING OLD BS
OLD BS
ATM SWITCH SERVING NEW BS
NEW BS
MOBILE STATION
HANDOFF REQ
70
ADD PARTY
ADD PARTY
SETUP
SETUP
SETUP
75
CONNECT
CONNECT
LEG THROUGH NEW BS ADDED
76
SETUP
SETUP
SETUP
SETUP
SETUP
77
CONNECT
CONNECT
CONNECT
CONNECT
CONNECT
78
UPSTREAM CONNECTION TO NEW BS ADDED
(COMPLETION OF DOWNSTREAM SYNCHRONIZATION)
RELEASE
RELEASE
RELEASE
DROP PARTY
DROP PARTY
RELEASE COMPLETE
RELEASE COMPLETE
RELEASE COMPLETE
ACK
LEG THROUGH OLD BS ADDED
(COMPLETION OF UPSTREAM SYNCHRONIZATION)
RELEASE
RELEASE
RELEASE
RELEASE
RELEASE
RELEASE COMPLETE
RELEASE COMPLETE
RELEASE COMPLETE
RELEASE COMPLETE
RELEASE COMPLETE
UPSTREAM CONNECTION TO OLD BS DROPPED

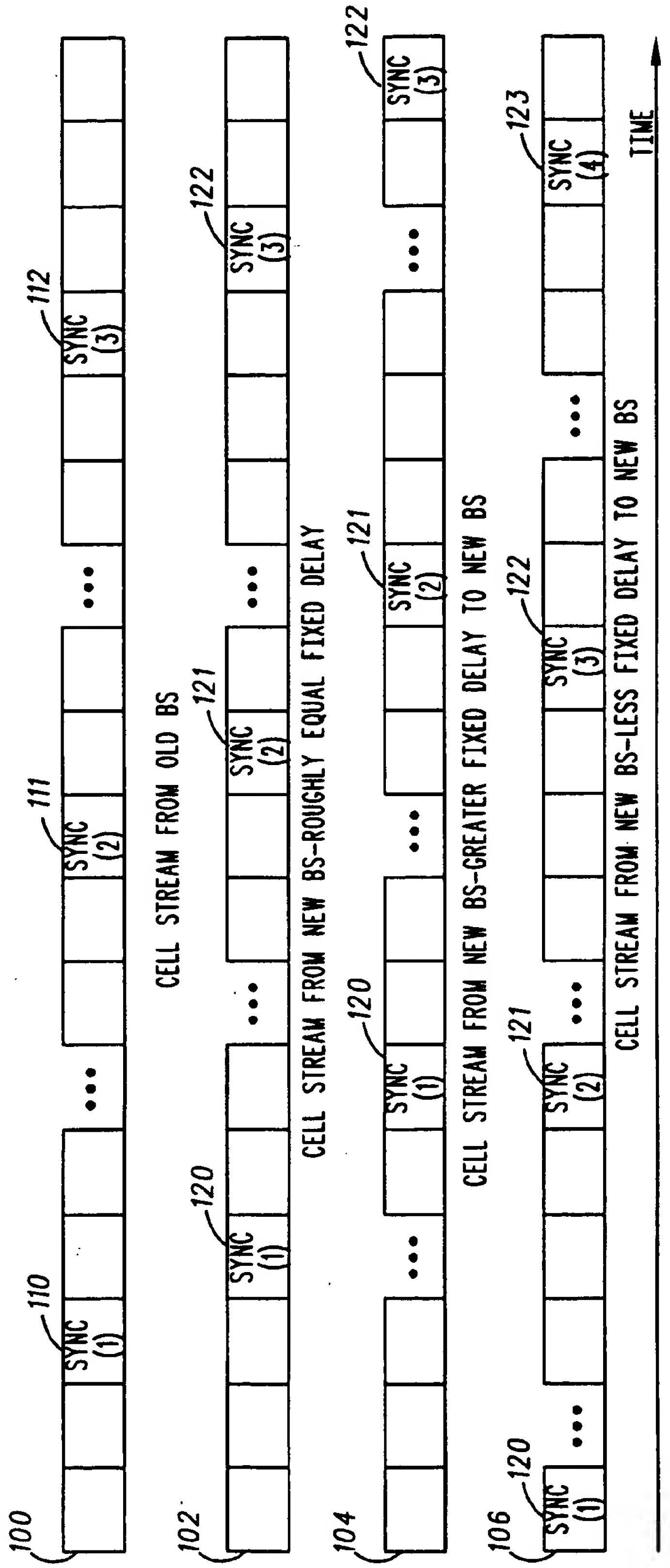

100
102
104
106
110
111
112
120
121
122
123
SYNC (1)
SYNC (2)
SYNC (3)
SYNC (4)
CELL STREAM FROM OLD BS
CELL STREAM FROM NEW BS-ROUGHLY EQUAL FIXED DELAY
CELL STREAM FROM NEW BS-GREATER FIXED DELAY TO NEW BS
CELL STREAM FROM NEW BS-LESS FIXED DELAY TO NEW BS
TIME

FIG.8

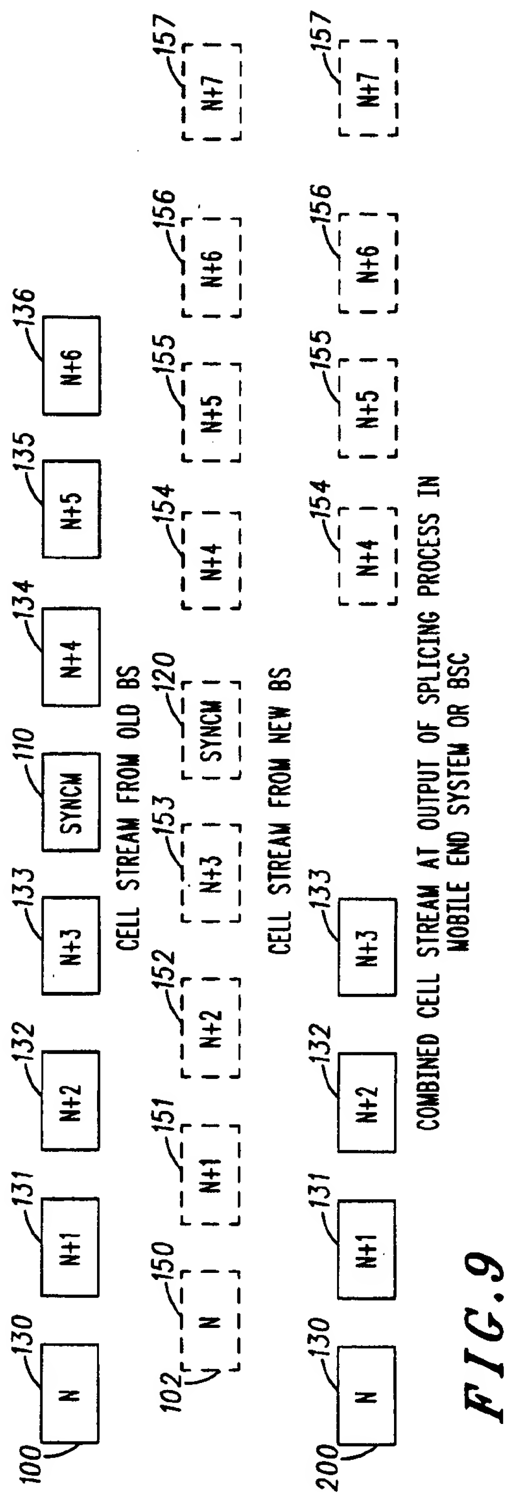

CELL STREAM FROM OLD BS
CELL STREAM FROM NEW BS
COMBINED CELL STREAM AT OUTPUT OF SPLICING PROCESS IN MOBILE END SYSTEM OR BSC
N
N+1
N+2
N+3
SYNCM
N+4
N+5
N+6
N+7
100
102
200
110
120
130
131
132
133
134
135
136
150
151
152
153
154
155
156
157

FIG.9

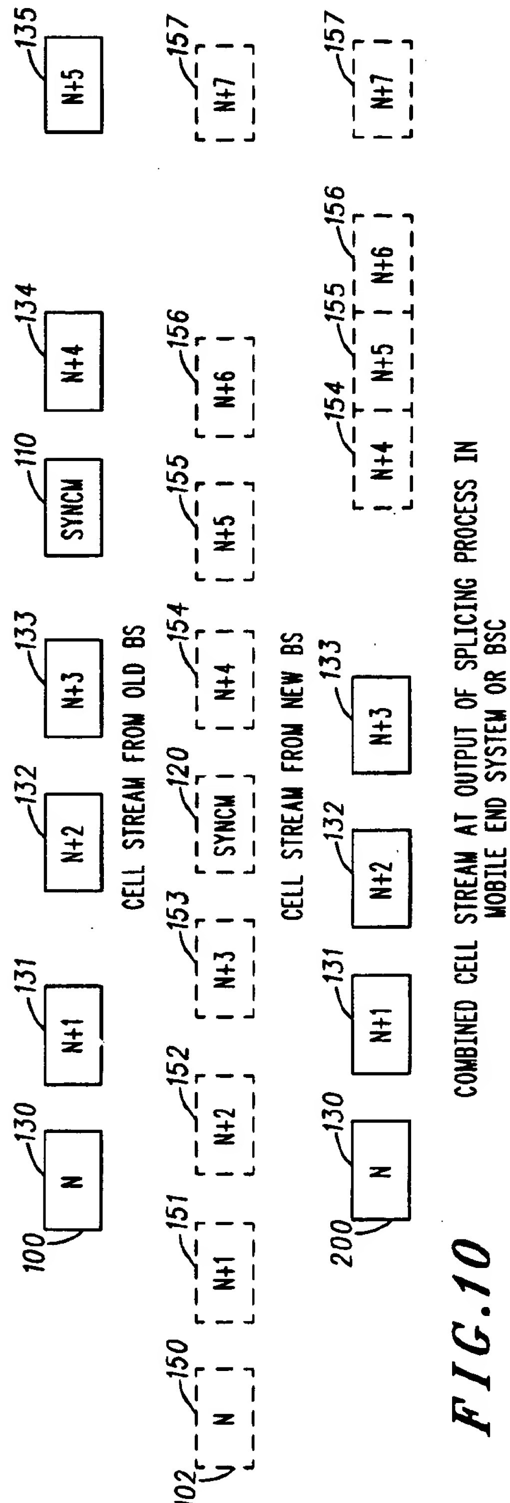

CELL STREAM FROM OLD BS
CELL STREAM FROM NEW BS
COMBINED CELL STREAM AT OUTPUT OF SPLICING PROCESS IN MOBILE END SYSTEM OR BSC
N
N+1
N+2
N+3
SYNCM
N+4
N+5
N+6
N+7
100
102
200
110
120
130
131
132
133
134
135
150
151
152
153
154
155
156
157

FIG.10

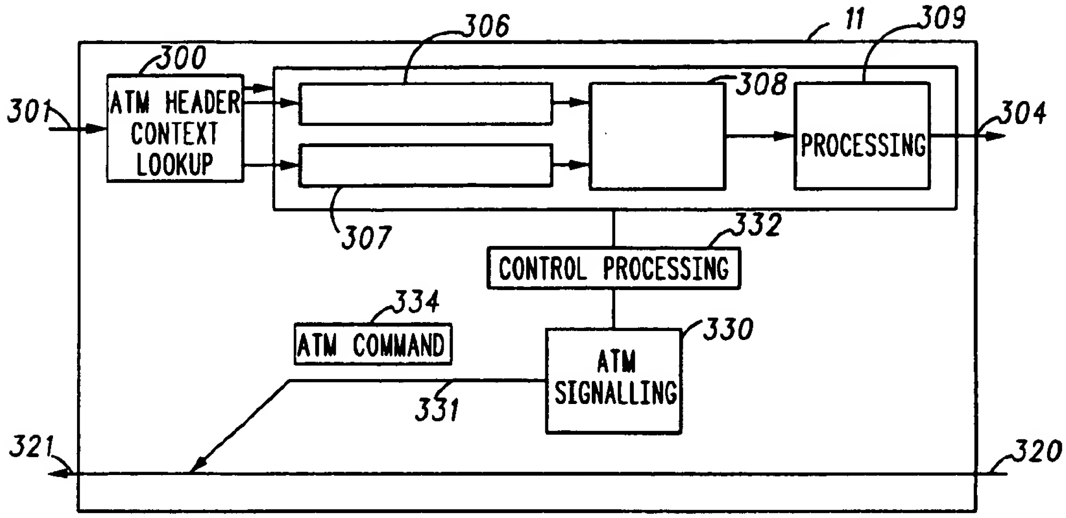

306
11
309
300
ATM HEADER CONTEXT LOOKUP
308
301
PROCESSING
304
307
332
CONTROL PROCESSING
334
ATM COMMAND
330
ATM SIGNALLING
331
321
320

FIG.11

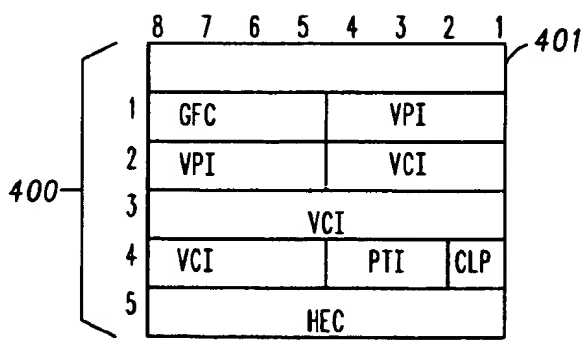

8 7 6 5 4 3 2 1
401
400
1
GFC
VPI
2
VPI
VCI
3
VCI
4
VCI
PTI
CLP
5
HEC

FIG.12

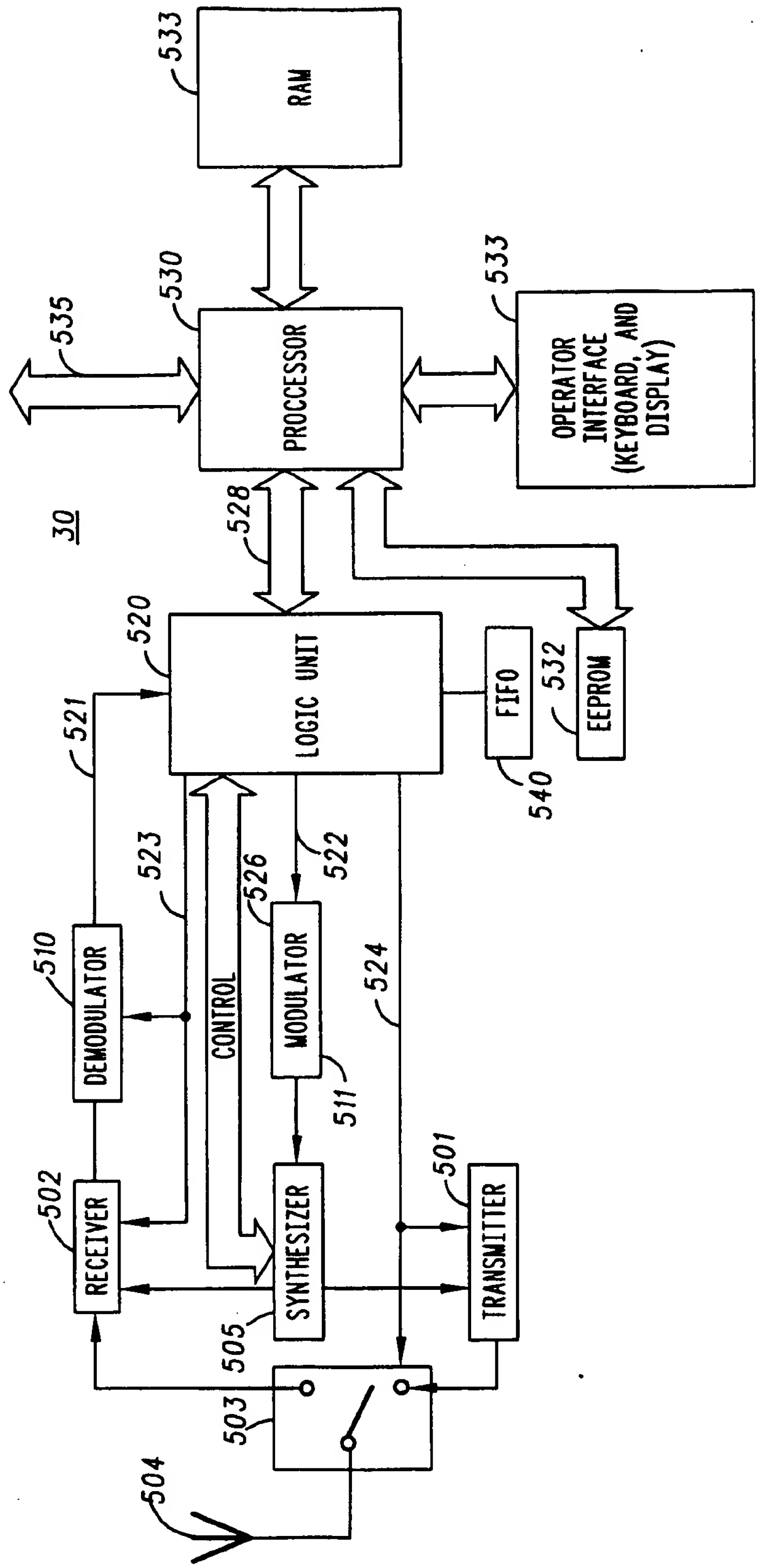

RAM
533
PROCESSOR
530
535
OPERATOR INTERFACE (KEYBOARD, AND DISPLAY)
533
30
528
LOGIC UNIT
520
FIFO
540
EEPROM
532
521
523
522
526
DEMODULATOR
510
CONTROL
MODULATOR
511
524
RECEIVER
502
SYNTHESIZER
505
TRANSMITTER
501
503
504

FIG.13

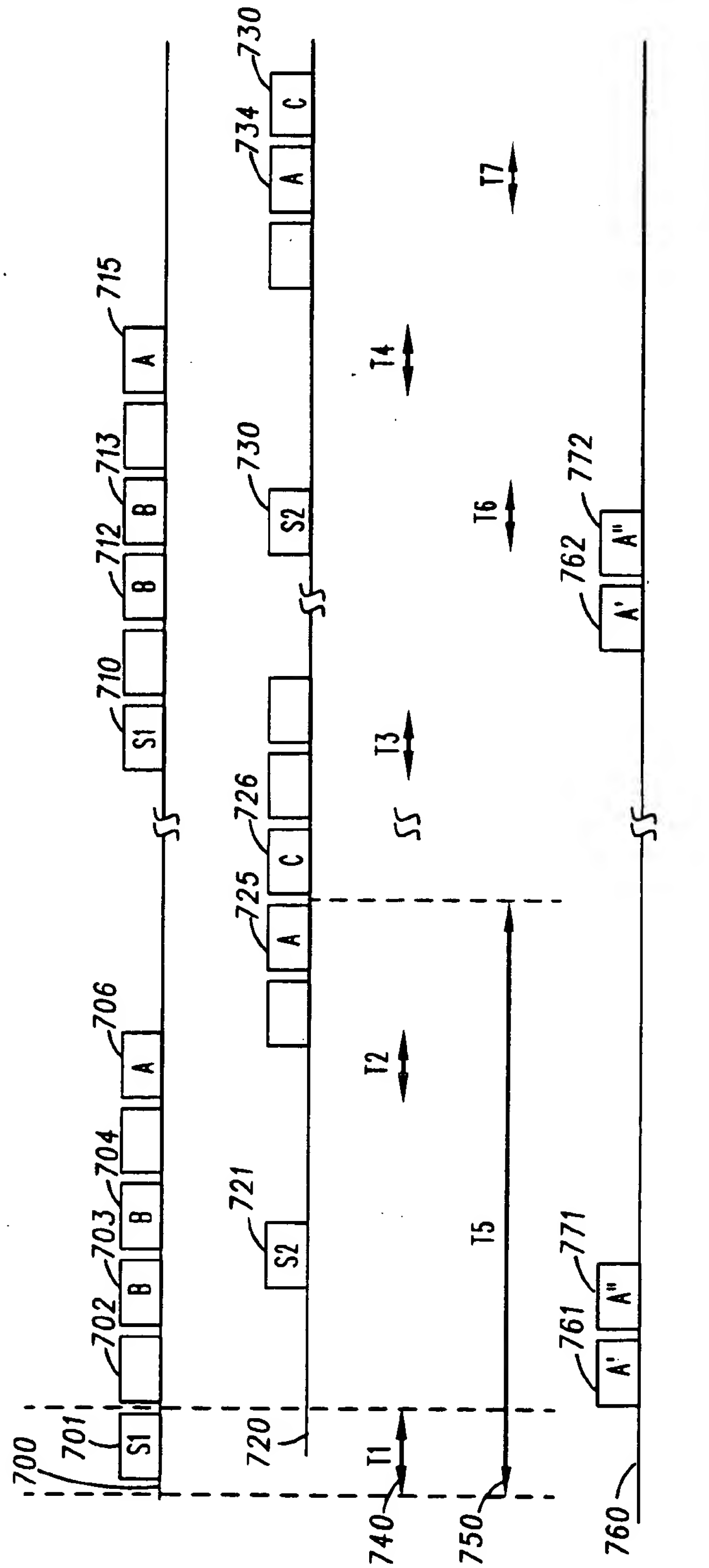

700
701
S1
702
B
703
B
704
706
A
710
S1
712
B
713
B
715
A
720
721
S2
725
A
726
C
730
S2
734
A
C
740
T1
T2
T3
T4
750
T5
T6
T7
760
761
A'
771
A"
762
A'
772
A"

FIG.14

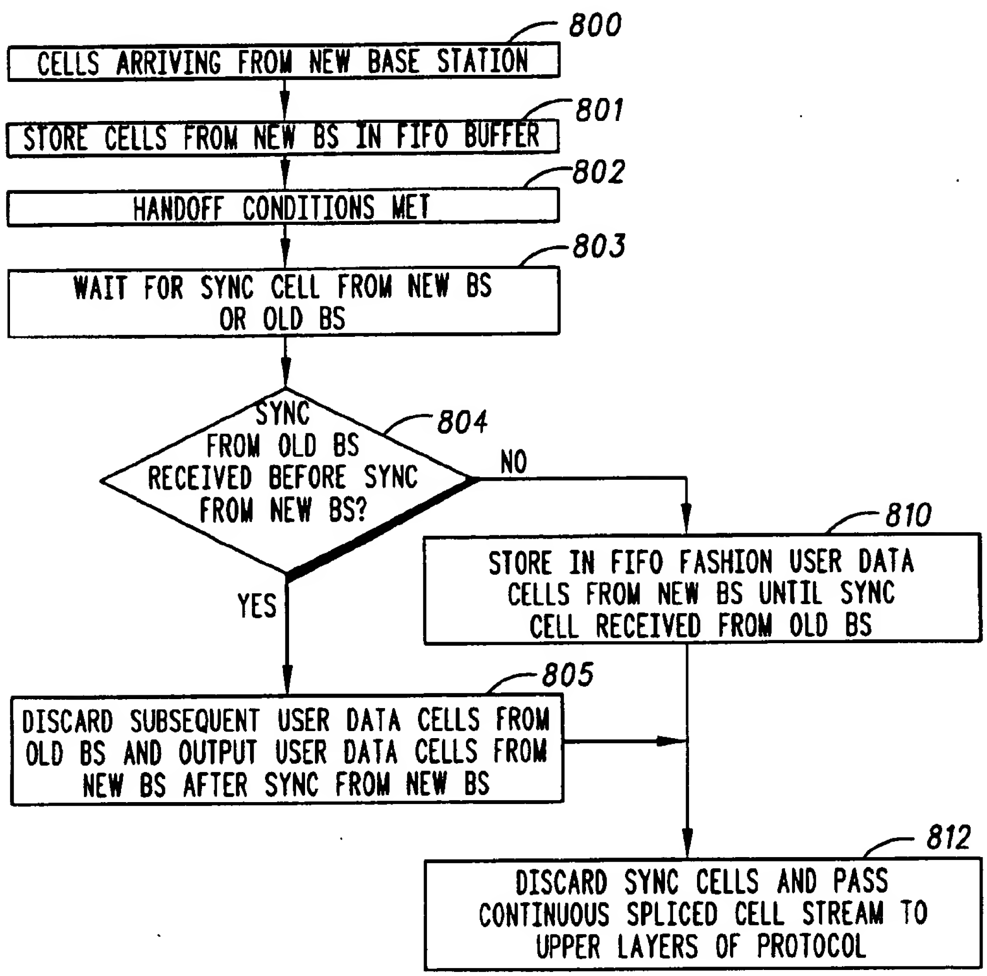

800
CELLS ARRIVING FROM NEW BASE STATION
801
STORE CELLS FROM NEW BS IN FIFO BUFFER
802
HANDOFF CONDITIONS MET
803
WAIT FOR SYNC CELL FROM NEW BS OR OLD BS
804
SYNC FROM OLD BS RECEIVED BEFORE SYNC FROM NEW BS?
NO
YES
810
STORE IN FIFO FASHION USER DATA CELLS FROM NEW BS UNTIL SYNC CELL RECEIVED FROM OLD BS
805
DISCARD SUBSEQUENT USER DATA CELLS FROM OLD BS AND OUTPUT USER DATA CELLS FROM NEW BS AFTER SYNC FROM NEW BS
812
DISCARD SYNC CELLS AND PASS CONTINUOUS SPLICED CELL STREAM TO UPPER LAYERS OF PROTOCOL

FIG.15

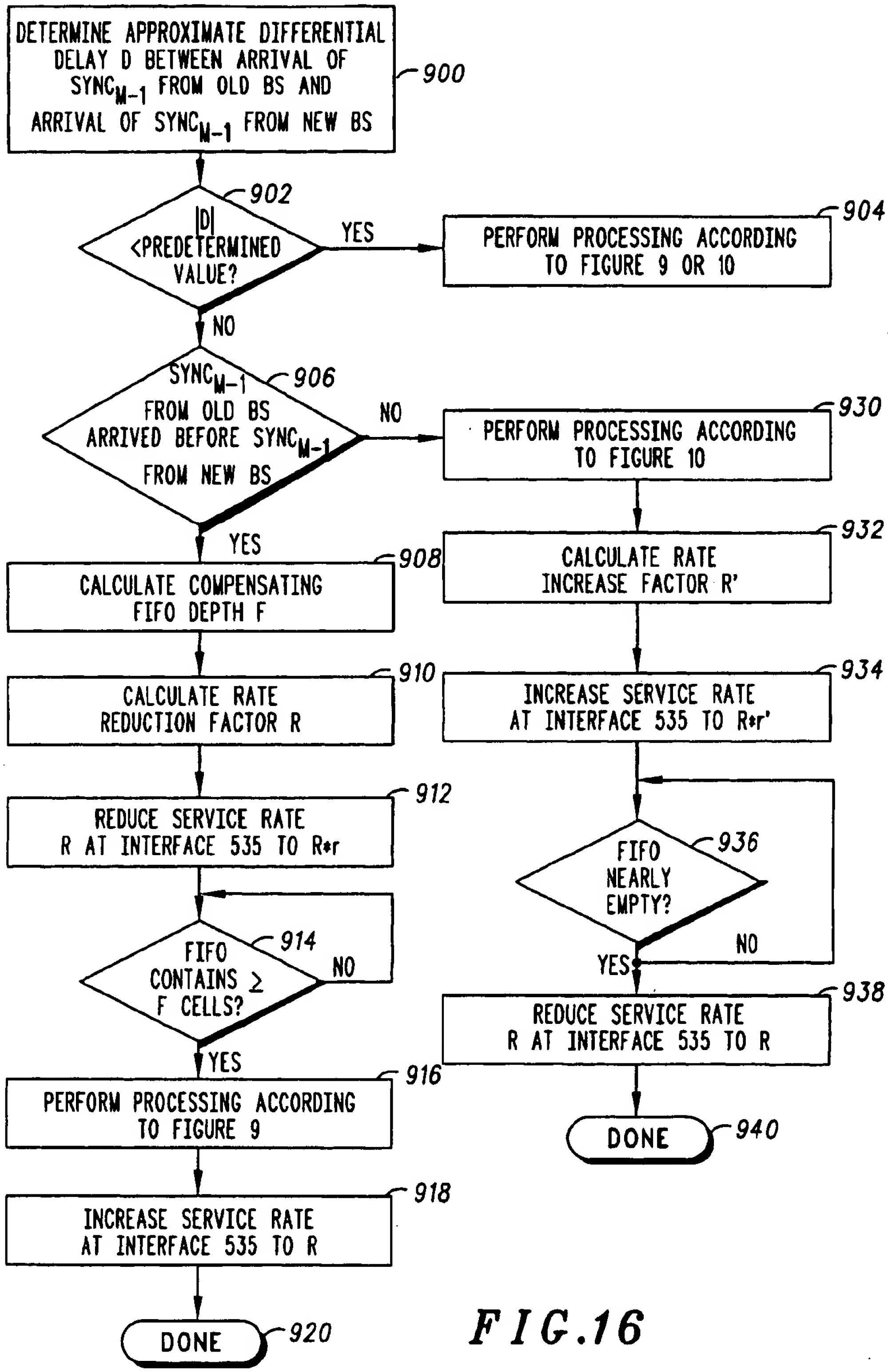

DETERMINE APPROXIMATE DIFFERENTIAL DELAY D BETWEEN ARRIVAL OF $SYNC_{M-1}$ FROM OLD BS AND ARRIVAL OF $SYNC_{M-1}$ FROM NEW BS
900
|D| <PREDETERMINED VALUE?
902
YES
PERFORM PROCESSING ACCORDING TO FIGURE 9 OR 10
904
NO
$SYNC_{M-1}$ FROM OLD BS ARRIVED BEFORE $SYNC_{M-1}$ FROM NEW BS
906
NO
PERFORM PROCESSING ACCORDING TO FIGURE 10
930
YES
CALCULATE COMPENSATING FIFO DEPTH F
908
CALCULATE RATE INCREASE FACTOR R'
932
CALCULATE RATE REDUCTION FACTOR R
910
INCREASE SERVICE RATE AT INTERFACE 535 TO R*r'
934
REDUCE SERVICE RATE R AT INTERFACE 535 TO R*r
912
FIFO NEARLY EMPTY?
936
NO
YES
FIFO CONTAINS ≥ F CELLS?
914
NO
REDUCE SERVICE RATE R AT INTERFACE 535 TO R
938
YES
PERFORM PROCESSING ACCORDING TO FIGURE 9
916
DONE
940
INCREASE SERVICE RATE AT INTERFACE 535 TO R
918
DONE
920

FIG. 16

METHOD OF HANDOFF BETWEEN BASE STATIONS IN A WIRELESS COMMUNICATIONS SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a division of application Ser. No. 08/615,381 filed on Mar. 14, 1996 now U.S. Pat. No. 5,940,381.

FIELD OF THE INVENTION

This invention relates to a wireless communications system utilizing asynchronous transfer mode (ATM communications) and it relates to remote station (generically referred to as a 'mobile station' though not necessarily mobile) for operation in such a system and, separately, a base station controller and a method of operation.

BACKGROUND OF THE INVENTION

In the modern telecommunications world, voice communications continue to be a popular mode of communication, but new services like video telephony, high speed data and short message services continue to expand on existing services. The arrival of new telecommunications services generates new requirements for telecommunications networks. New telecommunications techniques (transfer modes) are required and offer possible advantages compared to existing techniques. Traditional transfer modes for wired communications are circuit switching, familiar in classical telephone services, and packet switching, familiar in telegraphy and modem short message service and data systems.

Asynchronous transfer mode (ATM) is a mode of fast packet switching which allows systems to operate at a much higher rate than traditional packet switching systems. Features which characterize ATM communications are: the ability for asynchronous operations between a sender clock and a receiver clock; transmission "cells" of pre-defined sizes; and addressing carried out in a fixed size header (that is not but time, frame position or other fixed characteristic). ATM communication is sometimes also referred to as asynchronous time division (ATD) communications.

Asynchronous transfer mode (ATM) is a mode of fast packet switching which facilitates switching systems that operate at a much higher rate than traditional packet switching systems. Features which characterize ATM communications are: the ability for asynchronous operations between a sender clock and a receiver clock; the concept of a "virtual connection" which is established for the lifetime of an information flow that comprises part or all of the communication; transmission "cells" of a fixed, standardized size; and connection identification carried in a fixed size header (that is not by time, frame position or other fixed characteristic). ATM communication is sometimes also referred to as asynchronous time division (ATD) communications. Other features of ATM communications are notions of a "service category", "traffic contract" and Quality of Service objectives that apply to the virtual connection. The expression "virtual connection" here is used to refer a virtual path and virtual circuit pair and "virtual connection identifier" means either a virtual path identifier (VPI) or a virtual circuit identifier (VCI) or both.

ATM communication has proven useful in high-value point-to-point land-line communication, for example, satellite links and undersea cables. ATM allows multiple simultaneous circuits, sometimes referred to as virtual circuits (VCs), to be established from end to end along the link.

European Patent No. EP0679042 of Roke Manor Research describes a mobile communications network with ATM as the transfer mode used in the switching infrastructure and describes steps to be taken in the mobile network switching infrastructure when a mobile terminal changes affiliation from one base station to another base station, as in a conventional handoff operation and when a mobile terminal communicates simultaneously through more than one base station. The transfer mode of the radio link is not described. International Patent Application No. WO94/28645 of The Trustees of Columbia University in the City of New York also addresses the use of ATM in a mobile communications system switching network and addresses distributed call set-up and rerouting in a mobile ATM based system with ATM switches.

A mobile communications network consists of a number of mobile end systems, a number of base stations, and a number of base station controllers, where the base stations and base station controllers are interconnected using an Asynchronous Transfer Mode (ATM) network. When a mobile end system moves from radio site (or "cell" or "zone") to another, it is necessary to execute a handoff between the corresponding base stations.

The standardized ATM architecture prohibits any ATM network (including a wireless ATM network) from misordering or duplicating ATM user data cells. In general, ATM networks should lose (i.e. by discarding) few, or preferably no, ATM user data cells at any time, including during handoff. Further, the ATM service architecture distinguishes between 'real time' and 'non-real time' service categories. In real time service categories, cell delay variation (CDV—the variability in the pattern of cell arrival events at the output of an ATM connection relative to the pattern of corresponding events observed at the input of the connection) is an element of quality of service. CDV is negotiated between the end systems (including mobile end systems) and the network (s). If a cell exceeds the agreed CDV, then it either is lost, or becomes useless to the end system when it is delivered; thus, a late cell is treated as if it were lost. Non-real time services are indifferent to CDV, but may be more sensitive to cell discard.

The arrangements described in the above prior art patent application are not optimal in their use of ATM resources in an access network, nor do those arrangements address communication using ATM as the transfer mode over-the-air.

International Patent Application No. WO94/32594 of NTT Mobile Communication Network, Inc. describes a cellular mobile radio communication system soft-handover scheme using code division multiple access (CDMA) where signals transmitted from different base stations are spread with different spread codes and simultaneously received at a mobile station with reception units in correspondence to different base stations. It is described how communication can take place in packets which include a call number, in case the mobile station deals with a plurality of calls, a sequence number and an identification number (ID) for the mobile station. It is explained how the same packet can be received at the mobile station from more than one base station or received at more than one base station from the same mobile station, to provide a reliable diversity handover scheme. The establishment of simultaneous communication through two base stations is described, without the completion of a handover process being described. It must be assumed that the completion of handover complies with pre-existing CDMA soft handover principals. The patent application also mentions that the packet communication scheme can be an ATM scheme.

Attention is turning to the use of ATM for the radio interface transfer mode of wireless communications. There is, for example, a need for wireless users to have access to wired ATM networks and existing ATM systems such as multi-media applications need a wireless platform providing multi-media support. It is also recognized that systems such as universal mobile telephone systems (UMTS) and existing wireless local area networks (LANs) cannot meet all future data user needs. Efforts to date have been in the use of ATM in the wireless extension of fixed infrastructure systems, such as local area networks (LANs) and integrated service data network (ISDN).

For private land mobile networks and cellular radio networks, circuit-switched frequency-division multiple access (FDMA) with or without time division multiple access (TDMA), as well as code division multiple access (CDMA) continue to be the available multiple access schemes for the radio interface. Each of these multiple access schemes has its advantages and disadvantages in different circumstances and the various schemes are generally incompatible with each other.

A mobile radio system is now envisaged using ATM as the transfer mode and using a novel multiple access scheme which has advantages over existing FDMA, TDMA and CDMA multiple access schemes. There is a need for a method of handover in such a novel system.

GLOSSARY OF TERMS

ATM Asynchronous Transfer Mode
BS Base station
BSC Base station controller
CDV Cell Delay Variation
CLP Cell Loss Priority
GFC Generic Flow Control
HEC Header Error Control
PTI Payload Type Identifier
VPI Virtual Path Identifier
VCI Virtual Circuit Identifier

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a mobile radio network.

FIGS. 2 through 6 are further block diagrams of the network of FIG. 1 showing a sequence of connection configurations.

FIG. 7 is a ladder diagram showing an exchange of signaling messages for a base station to base station handoff.

FIG. 8 is a time sequence diagram showing the timing relationship of cell streams during different handover scenarios.

FIG. 9 is a time sequence diagram illustrating a splicing operation in a first scenario.

FIG. 10 is a time sequence diagram illustrating a splicing operation in a second scenario.

FIG. 11 is a block diagram of a BSC in accordance with one aspect of the invention.

FIG. 12 is a bit map diagram of an ATM header with physical layer information added.

FIG. 13 is a block diagram of a mobile station.

FIG. 14 is a flow diagram illustrating operations performed by the mobile station of FIG. 13.

FIG. 15 is a timing diagram illustrating power saving features of the mobile station of FIG. 13.

FIG. 16 is a flow diagram showing further operations performed by the mobile station of FIG. 13.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a radio communications system **10**, which comprises a number of base station controllers (BSCs) of which two are shown as BSCs **11** and **12**, each controlling a number of base stations (BSs) **13**, **14**, **15** and **16** by way of example. Each BSCs, e.g. BSC **11** communicates with associated base stations **13** and **14**, with one or more fixed ATM end systems **17** and with other BSCs, e.g. BSC **12**, by means of a fixed ATM network **20**, which is implemented using existing standards and implementation agreements. The fixed ATM network **20** is comprised of a mesh of interconnected ATM nodes, of which three (nodes **21**, **22** and **23**) are shown in FIG. **1** by way of example.

Node **21** is connected to BSC **11** and BSs **13** and **14** and to node **22**. Node **22** is connected to BSC **12**, via a first port **24** of BSC **12**, and fixed to end system **17**. Node **23** is coupled to BSC **12** via a second port **25** of BSC **12** and is coupled to BSs **15** and **16**. Thus different configurations are possible and a node, e.g. node **21**, can pass downstream traffic from the fixed end system **17** to the BSC **11** and from the BSC **11** to a BS **13** while simultaneously passing upstream traffic from a BS **13** to the BSC **11** and from the BSC **11** to the fixed end system **17**. Alternatively, a BSC, e.g. BSC **12** can effectively divide the network into a sub-network on the mobile side and a sub-network on the fixed side.

In a real system, there will be many more nodes in the network **20** and any given link between the fixed end system and a base station via a BSC may pass through many nodes in sequence.

The network **10** further includes a number of mobile ATM end systems (alternatively "remote stations" and hereafter simply "mobile stations"), which communicate with the base stations by radio. One such mobile station **30** is shown by way of example. An object of end-to-end communication is the establishment of one or more ATM virtual connections between the mobile station **30** and one or more fixed end systems **17**. The mobile end system moves during the lifetime of the ATM connection, moving from the radio cell covered by the first base station to the radio cell covered by the second base station and so on. First ATM radio channel **31** is provided between mobile station **30** and base station **13** and second ATM radio channel **32** is provided between mobile station **30** and base station **14**. First and second ATM radio channels **31** and **32** support communication though ATM cells over a common frequency band and are described in more detail below. Base station **13** has a connection identifier memory **35** and base station **14** has a connection identifier memory **36**.

As the mobile end system travels from radio cell to radio cell in the direction of the arrow, it is desirable that the connection segment between the old base station and the BSC (for inter-base station handoffs), as well as the connection segment between the new anchor BSC and the old BSC (for inter-BSC handoffs) be removed from the connection, so as to release resources and minimize fixed and variable delay. To the extent possible, it is desirable to use existing ATM standards and implementation agreements. In particular, mobile-specific modifications to the fixed ATM network should be avoided.

There is a trade-off to be made with regard to the use of ATM virtual paths (VPs). A VP is an aggregation of virtual circuits, which can be processed by an ATM VP switch as a group rather than individually. If all virtual circuit connections (VCCs) to a single mobile end system are aggregated into a single VP connection, handoffs can be executed on the

aggregate, minimizing processing. However, the service category and quality-of-service provided for the VP are at least as stringent as those for the most sensitive VCC that uses the virtual path connection (VPC), and the traffic contract for the VPC is at least as large as the sum of the traffic contracts for all of the possible VCCs (noting that VCCs can be added after the VPC is established). This approach is more efficient in this respect than arrangements in the prior art.

Although the preferred embodiment of the present invention uses switched VCCs from the BSC to the BS, an alternative embodiment uses switched VPCs (i.e. established on demand using signaling). In this case, there is a VPC for each mobile device. The traffic contract is sufficient to handle only existing VCCs and some additional margin; it can be adjusted as needed during a handoff or by means of signaling renegotiation.

FIGS. **2** through **6** represent a sequence of connection configurations in the system of the preferred embodiment of the present invention, as the mobile end system moves. The heavy lines in each figure show the connection configuration.

A BSC, e.g. BSC **11** in FIG. **2**, is the endpoint of a point-to-point bidirectional virtual circuit connection (VCC) **40**, where the other endpoint of the VCC is the fixed end system **17**. Thus, BSC **11** appears to the ATM network **20** to be an end system. The BSC **11** is also an endpoint of two or more virtual connections, which may be VCCs or virtual path connections (VPCs). One of these virtual connections, which is designated the downstream virtual connection **41**, is a unidirectional point-to-multipoint connection, having its root at the BSC **11**, such that ATM cells flow from the BSC to all BSs that are presently joined to the downstream virtual connection. The other virtual connection, which is designated the upstream virtual connection **42**, is a unidirectional point-to-point connection, such that ATM cells flow from a single base station **13** to the BSC **11**. Point-to-point and point-to-multipoint unidirectional virtual connections and the means for signaling to obtain them are defined in the ATM standards. The BSC **11** splits the two directions of the connection between itself and the fixed end system by switching cells received from the fixed end system **17** to the downstream virtual connection **41** and by further switching cells received on the upstream virtual connection **42** towards the fixed end system.

FIG. **2** shows the initial configuration of ATM connections. An end-to-end communication has been established by means known in the art, including establishment of the upstream and downstream virtual connections, by means of standardized ATM signaling protocols. The downstream virtual connection **41** has only one leg, so is indistinguishable in the figure from a point-to-point connection. Thus, cells sent by the fixed ATM end system **17** are forwarded by the BSC **11** to the base station **13** serving the mobile station **30**, and cells sent by the mobile station **30** are forwarded by the base station **13** to the BSC **11**, and thence to the fixed end system **17**.

FIG. **3** shows the configuration of the ATM connections during a BS—BS handoff from the old base station **13** to a new base station **14**. The BSC **11** has determined that the handoff is available or required. This determination may take one a number of forms. In the preferred embodiment the mobile station **30** reports signal strength and bit error rate measurements to the BSC **11** indicating the need for a handoff. Either the mobile station **30** reports to the BSC **11** the detection of synchronization cells (F3 cells) transmitted by base station **14** and identifying base station **14** or base station **14** reports to the BSC **11** the detection and reception of ATM cells from the mobile station **30**.

The BSC **11** uses existing ATM call control signaling protocols to add a leg **50** to the downstream connection, having as its destination the new base station **14**. It further uses the signaling protocols to establish an upstream connection **51** to the new base station **14**. In the downstream virtual connection, the ATM network node **21** bifurcates the ATM cell stream into connections **41** and **50**. This is achieved by the BSC **11** providing the node **21** with ATM signaling requesting the bifurcation.

Thus, in FIG. **3**, the mobile station **30** is receiving two copies of the cell stream that originated in the fixed end system **17**, and the BSC **11** is receiving two copies of the cell stream that originated in the mobile station **30**. Initially, the mobile station and the BSC each discard cells received from the new base station **14**, and continue to consume cells received from the old base station **13**. After synchronization (described below with reference to FIGS. **8** and **9**) is performed, the mobile end system and the BSC discard cells received from the old base station **13** and consume cells received from the new base station **14**.

FIG. **4** shows the configuration of the ATM connections after the BS—BS handoff. After it has completed synchronization, the BSC uses the existing ATM call control protocol to release the old upstream connection **42**. Similarly, after it has completed synchronization, the mobile station **30** drops the old leg of the downstream connection **42**.

FIG. **5** shows the configuration of the ATM connections for a BSC-to-BSC handoff as mobile station **30** moves from the coverage area of BS **14** to the coverage area of base station **15** served by BSC **12**. Mobile station **30** reports through base station **14** that it is receiving cells from base station **15** and optionally reports the signal strength and/or bit error rate of those cells. The preferred operation is that mobile station **30** passes these cells to BSC **11** and BSC **11** examines the error rate within the cells by performing error detection on the cells.

As a third alternative, base station **15** reports to BSC **12** via node **23** the detection and reception of ATM cells from mobile station and BSC identifies that BSC **11** is the BSC serving the mobile station and reports to BSC **11** that there is an opportunity for a handoff. BSC **12** identifies BSC **11** as the serving BSC either by interrogation of surrounding BSCs or by information reported to it periodically from surrounding BSCs as to the identification numbers of mobile station being served by the surrounding BSCs.

Node **21** (or some other node) is instructed by BSC **11** to bifurcate the downstream connection **50** and establish a connection **60** to BSC **12**, where the connection is made through first port **24**. BSC **12** in turn establishes a connection **61** through its other port **25** to base station **15** via node **23**. BSC **12** then establishes an upstream connection **62** to BSC **11**. BSC **11** combines the upstream connection **62** with the upstream connection **51** in a manner described below.

Finally, as shown in FIG. **6**, BSC **11** instructs node **21** to drop downstream connection **50** and mobile station **30** drops the upstream connection **51**.

FIG. **7** is a ladder diagram showing the exchange of signaling messages for a BS-BS handoff as shown in FIGS. **2**, **3** and **4**. The messages indicated by thin lines are standard ATM connection control signaling messages. The message **70** indicated by the dotted line is an additional messages sent between the BSC **11** and the mobile station **30**. The vertical

lines show elements of the connection configuration. Messages 75 and 76 are setup and connect messages for the downlink connection between the base station 14 and the mobile station 30. Messages 77 and 78 are setup and connect messages for the uplink connection between the base station 14 and the mobile station 30

In the process of ATM signaling to add or remove legs from connections, there is a correlation identifier which is part of the signaling message sent (by the mobile station or the BSC) to the network and transferred end-to-end. This identifier maps the VPI and VCI combinations between the connection for the old base station with the VPI and VCI combination for the connection to the new base station. Each of the messages indicated by the thin lines in FIG. 7 carries this correlation identifier.

Reference is now made to the handoff process and the appropriate VPI and VCI selection in the downlink connection setup message 75 in FIG. 7 in which the base station 14 sends a setup message to the to the mobile station 30. The VPI is generally unique for the connection between the two end points and is selected by the base station 14. The VCI can be the same as for the cell stream from base station 13 to mobile station 30.

Mobile station 30 receives from BSC 11 a correlator identifier identifying that the new connection (having a new VPI and VCI) is the same as the existing connection through the old base station. Mobile station 30 is able to distinguish between the cell streams by virtue of the different VPI/PCI combinations. BSC 11 instructs mobile station 30 to initiate a handover to the new virtual connection identified by the correlation identifier and the new VPI/VCI combination.

It is preferred that across the whole network 20 the whole domain of VPI numbers, at least for downlink connections, is subdivided into mutually exclusive sub-groups of VPIs (or VPIs and VCIs) and that any given base station uses only its allocated sub-group of VPIs. These are stored in the connection identifier memory 35 or 36 for the base station. Adjacent base stations are, as far as practicable, not allocated the same subgroup of VPIs. This has an advantage similar to the reuse of frequencies in an FDMA system in that the VPI sub-groups are re-used across the network and confusion is avoided at the overlapping regions of base stations or the overlapping regions of networks. In one of the final steps of the handoff process, the VPI number may be changed to a new VPI number selected by the new base station. In this embodiment the VPI number is temporarily out of the sub-group of VPI numbers allocated to the base station and is chosen from within that sub-group when it is updated.

In operation, an ATM communication connection is established between the mobile station 30 and the old base station 13 with at least a first virtual connection identifier (preferably a VPI) selected from the connection identifier memory 35. When it is determined that handoff conditions are met for a handoff to the new base station 14, base station 14 selects a second virtual connection identifier (including a second virtual path identifier and a second virtual circuit identifier) for a downlink connection between the new base station and the mobile station. In the preferred method, the new base station 14 at least temporarily selects the existing virtual path identifier and the existing virtual circuit identifier as the new virtual path identifier and the new virtual circuit identifier for uplink communication. At least one of the second virtual path identifier and the second virtual circuit identifier (preferably the former) is later changed to a new value.

Thus the first base station 13 is provided with a first sub-group of virtual path identifiers in memory 35 for use in communications with the mobile station 30 and the second base station 14 is provided with a second sub-group of virtual path identifiers in memory 36 for use in communications with the mobile station 30, which is mutually exclusive to the first sub-group of virtual path identifiers, and the second virtual path identifier is (later, if not initially) selected by the base station from the second sub-group.

Each base station communicates with its mobile stations through ATM cells and each base station transmits physical layer synchronization cells using its own synchronization timing. ITU Rec. 1.610 describes various types of cells including F3 cells and F5 cells. Synchronization takes place in the physical layer using F3 cells and in the ATM layer using F5 cells.

In the physical layer, the physical radio channel is divided into frames. One frame comprises a fixed number of cells, there being preferably more than 10 and less than 50 cells per frame. Each Nth cell is a synchronization cell (where $10<N<50$) which can be considered to be an F3 cell. Thus the frames received by the mobile station 30 from base station 13 may be offset from the frames received from base station 14. The offset is not necessarily a whole number of cells, but is entirely arbitrary. This is advantageous from a cell planning point of view. Operation takes place at a basic frame rate, with all transmissions being at integer multiples or devisors of the frame rate. A virtual connection comprises one or a plurality of cells per frame, depending on the desired data rate and the available capacity.

Each cell has a header (described below with reference to FIG. 12) identifying the VPI and the VCI. Cells with the same VPI and VCI are collected by the base station (in the uplink direction) or the mobile station (in the downlink direction) into blocks of cells. The first cell of each block is an ATM synchronization cell, which can be considered to be an F5 cell.

FIG. 8 is a time sequence diagram, showing the timing relationship for blocks of cells between the cell stream 100 from the old base station 13 and the cell stream 102 from the new base station 14 in scenarios where the fixed delay from the new base station is approximately the same as the fixed delay from the old base station. The figure also shows an alternative cell stream 104 from the new base station where the fixed delay from the new base station is greater than the fixed delay from the old base station and a further alternative cell stream 106 where the fixed delay from the new base station is less than the fixed delay from the old base station.

Synchronization cells 110, 111 and 112 are present in the cell stream from the old base station 13 at intervals of fixed numbers of cells, where the interval is known to the base station, mobile end systems and BSC. Synchronization cells 120, 121 and 122 are present in the cell stream from the new base station 13 at the same intervals. (In cell stream 106 a further synchronization cell 123 is shown.) In each case, the differential fixed delay is approximately equal to the difference in arrival times between a synchronization cell from the old BS and the corresponding cell from the new BS. Due to the effect of delay jitter and queuing delays, the exact difference is not known. In each case a splicing arrangement is needed to seamlessly end the cell stream 100 from the old base station and pick up the cell stream 102, 104 or 106 from the new base station without omitting or repeating cells.

FIG. 9 is a time sequence diagram, showing the operation of the splicing process carried out in the mobile end system, where it acts upon the two legs 41 and 50 of the downstream

virtual connections that arrive from the old base station and the new base station 13 and 14, respectively. The splicing process also occurs in the base station controller 11 (the 'anchor' BSC), where it acts upon the two upstream virtual connections 42 and 51 that arrive from the old base station and the new base station, respectively.

FIG. 9 shows the cell streams 100 received from the old base station, the cell stream 102 received from the new base station, and the cell stream 200 emerging from the splicing process, respectively. For illustration, cells received from the new base station are in phantom outline. User data cells 130, 131 etc. are designated sequentially (i.e., n, n+1, n+2, etc.), and synchronization cells 110 are designated sequentially (i.e., $sync_m$, $sync_{m+1}$, etc.), where any cell so designated is identical whether received from the old base station or the new base station. At the beginning of the splicing process, user data cells n, n+1, n+2, n+3 received from the old base station become the output of the splicing process. The splicing process awaits synchronization cells. If synchronization cell 110 ($sync_m$) is received first from the old BS, then the splicing process discards subsequent user data cells 134, 135, 136 etc. (labeled n+4, n+5, etc) from the old BS, awaits the corresponding synchronization cell 120 ($sync_m$) from the new base station, discards the synchronization cell 120, and then the output of the synchronization process becomes user data cells 154, 155, 156, 157 etc. (labeled n+4, n+5, etc.), received from the new BS.

Referring to FIG. 10, if synchronization cell 120 ($sync_m$) is received first from cell stream 102 from the new BS 14, then the splicing process stores, in a first-in-first-out (FIFO) fashion, user data cells 154, 155 and 156 (n+4, n+5 and n+6), until the corresponding synchronization cell 110 ($sync_m$) is received from the old BS; at that time, the stored user data cells 154, 155, 156 are removed from the FIFO storage, and become the output of the splicing process; when the FIFO storage becomes empty, then subsequent user data cells 157 received from the new BS become the output of the splicing process.

Cells may need to be removed from the FIFO storage at a rate which is paced by the peak cell rate, sustainable cell rate or available cell rate.

Referring now to FIG. 11, details of a BSC 11 (or 12) are shown. The BSC comprises an ATM switch 300 having input port 301 arranged to receive virtual connections 42, 51 and 62 (and the downlink part of connection 40) from node 21 of the ATM network 20 (these virtual circuits being bundled by node 21 over the same virtual path). It has combiner 303 coupled to switch 300 and an output port 304 for coupling to node 21 (or to some other node in the sub-network on the fixed side). Combiner 303 comprises buffers 306 and 307, splicing element 308 and processor 309. The BSC 11 also has an input port 320 for coupling to node 21 (or to some other node in the fixed end system subnetwork) coupled to an output port 321 for coupling to node 21 or some other node in the sub-network on the mobile side. In addition it has ATM signaling circuit 330 having an output 331 coupled to output port 321 ad it has control processing element 332 coupled to the combiner 303 and the ATM signaling circuit 330 for control of those elements.

In operation, the scenario will be considered where a BS-to-BS handover is in progress at the stage shown in FIG. 3. Virtual connection 42 from base station 13 and virtual connection 51 from base station 14 are received on port 301 (together with the downlink part of connection 40 which need not be considered). ATM cells of connections 40 and 51 are presented at port 301 with the same virtual path numbers. ATM switch 300 separates these cell streams by their different VCIs and passes them to buffers 306 and 307. One of buffers 306 and 307 acts as a FIFO to buffer up cells arriving from the new base station (over connection 51) when the synchronization cell 120 arrives from connection 51 before the synchronization cell 110 from connection 40. Processor 309 removes the synchronization cells 110 and 120 and performs the other operations of the splicing process described above, including the control of the rate of removal of the cells from the buffers 306 and 307.

For the downlink direction, ATM signaling circuit 330 issues ATM commands 334 and inserts these into the downlink connection to the ATM network node 21. These messages include messages to: (a) establish new connections; (b) add new legs to existing connections; (c) remove legs from existing connections and (d) drop connections. Thus ATM signaling circuit 330 issues an instruction to node 21 to add leg 50 to existing connection 41.

Thus it has been described how existing point-to-multipoint and point-to-point unidirectional ATM connection configurations are used in a novel way, along with standardized connection control signaling procedures, to transport a bifurcated ATM cell stream during a handoff. Existing, standardized, operations and maintenance (OAM) cell formats and procedures are extended to synchronize the handoff such that duplication and misordering are prevented, and loss is avoided. For real-time service categories, the synchronization procedures provide compensation of differential delay between the old path of the virtual connection and the old path of the virtual connection, so that CDV objectives can be met.

The arrangement has the advantages that: cells are not duplicated or misordered during handoff; for non-real time services, cells are not discarded if buffers are dimensioned properly; for real time services, CDV objectives are met, or cells are discarded; further, if sufficiently conservative CDV objectives are set, cell discard does not occur; the path of a connection follows a spanning tree from the anchor base station to the mobile end system; thus, the number of connection segments (and the corresponding resources) is minimal; standardized ATM layer and ATM signaling protocols are built upon but not modified.

In this manner, combining of virtual circuits on the uplink and bifurcating of virtual circuits on the downlink is achieved.

The above description has set out the elements of the network infrastructure and their operation. The features of the mobile station 30 and the novel air interface between the mobile station 30 and its base station are now described.

It has been described that in the radio interface physical layer the radio channel is divided into frames, each frame comprising a fixed number of cells and each Nth cell being a synchronization cell (where $10<N<50$). FIG. 12 shows a bit map for the header of a cell, whether this is a data cell or a synchronization cell. ATM cell header part 400 comprises 5 octets. Four bits are for generic flow control, eight bits are for VPI, 16 bits are for VCI, 3 bits are for payload type identifier, one bit is for cell loss priority and one octet is for header error control. It can be seen that the VPI and the VCI are a fixed resource. There is a need to make efficient use of this resource. The PTI field identifies, among other things, whether the cell is a synchronization cell or some other cell type.

Added to the ATM cell header part 400 is a physical layer part 401. Physical layer part 401 is shown as comprising

only one octet, but may be longer. For present purposes, it is illustrated as having sufficient space for a cell sequence number of 8 bits.

The header shown in FIG. 12 accompanies a payload of 48 octets. This is fixed in the ATM network but may have a trailer added in the physical layer, for example giving extra cyclical redundancy checking or other error control code.

As an alternative arrangement to that illustrated in FIG. 12, physical layer header 401 is omitted and a cell sequence number is inserted in the ATM header 400 in place of some of the fields shown. For example, the GFC field can be omitted and the four bits of this field together with four bits of the VPI field (or four bits of the VCI field) can be used as a sequence number field. The sequence number field is preferably large enough to span several blocks of cells. If, for example, the block size is 64 cells, an 8-bit sequence number field spans 4 blocks before it has to repeat. By providing a block sequence number in each block, these two numbers together uniquely identify a cell over a very large number of cells.

Referring to FIG. 13, elements of an example of a mobile station 30 in accordance with an aspect of the present invention are shown. The mobile station comprises a transmitter 501 and a receiver 502 coupled to an antenna switch 503 and, through the antenna switch, to an antenna 504. A synthesizer 505 is coupled to each of the receiver 502 and the transmitter 501. A demodulator 510 is coupled to receiver 502. A modulator 511 is coupled to the synthesizer 505. A logic unit 520 is coupled via data lines 521 and 522 to the demodulator 510 and modulator 511, respectively, and is coupled by control lines 523 and 524 to the demodulator 510 and the receiver 502 and to the transmitter 501 and the antenna switch 503 respectively. A control bus 526 is coupled between the logic unit 520 and the synthesizer 505. Synthesizer 505 and control bus 526 are optional, as it is not necessary for the mobile station to perform FDMA channel changing, nor is it necessary to perform CDMA spreading and de-spreading. Instead of an antenna switch 103, a duplexer can be used, allowing simultaneous receiving and transmitting of ATM cells. Logic unit 520 has an associated FIFO buffer 540.

Coupled to the logic unit 520 via a digital bus 528 is a processor 530. Coupled to the processor 530 is a random access memory (RAM) 531, a program memory in the form of electrically erasable programmable read-only memory (EPROM) 532, an operator interface 533 such as a keyboard and display and an I/O interface 535.

In operation, the logic unit 520 receives data for transmission from the processor 530 and generates ATM cells. The ATM cells are created by assigning an ATM header to each cell comprising a virtual path identifier and virtual circuit identifier for the particular transmission. Logic unit 520 adds a physical layer header (and trailer if required) providing a sequence number for each sequential cell and supplies the resultant transmission burst data to modulator 511. It will, of course, be appreciated that alternative arrangements can be provided. For example the addition of the physical layer header and trailer, can be carried out in processor 530.

The logic unit 520 passes the transmission burst data to the modulator 511 bit-by-bit and provides a transmitter key-up signal on control line 524 (at the same time switching antenna switch 503 to the lower position as shown). The logic unit 520 controls the timing of key-up of the transmitter 501, so that each transmission burst is transmitted at a carefully selected time in a frame.

When the transmitter 501 is not keyed up for transmission, the control line 524 causes the antenna switch 503 to switch to the upper position as shown, allowing ATM cells (with physical layer header and trailer) to be received via the antenna 504 to the receiver 502 and demodulated by the demodulator 510 and passed to the logic unit 520.

The received ATM cells are identified in the logic unit 520 by the virtual path and virtual circuit identifier in the header 400 and only cells received with the appropriate virtual path and virtual circuit identifier are selected by the logic unit 520 for further processing. Logic unit 520 orders the received ATM cells in the correct order as defined by the sequence numbers in the physical layer headers 401. Logic unit 520 also performs error correcting in a manner known in the art. When the data has been corrected, the data is passed on to the processor and to the upper layers of the protocol.

The processor 530 can perform the operation of assembling and ordering the ATM cells and can perform the error correcting if desired, but these functions can generally be performed more quickly in the logic unit 520.

Logic unit 520 provides wake-up signals over control line 523 to receiver 502 (and to other parts of the mobile station) causing receiver 502 to power up and power down. Powering up and down of a receiver in response to a signal is readily understood by one skilled in the art and details such as an electronic switch and a battery power source need not be described here.

Logic unit 520 also controls synthesizer 505 via control bus 526 to select appropriate frequencies for transmission and reception depending on the particular frequencies of the system and the modulation scheme and other aspects of the physical layer.

FIG. 14 is a timing diagram for the purposes of illustrating operation of the mobile station 30 of FIG. 13. In the upper part of the diagram there is a cell stream 700 which is the activity in real time on the downlink of the first ATM radio channel 31. The cell stream 700 comprises a number of transmission bursts 701, 702 etc., each burst comprising one ATM cell with its radio interface header and trailer. For the purposes of illustration, the first burst 701 shown comprises a synchronization cell S1. This is a physical layer synchronization cell, distinct from synchronization cells 110 and 120 of FIGS. 9 and 10 which are ATM layer synchronization cells. This burst 701 and later synchronization cell burst 710 are separated by one frame of N ATM cell bursts 702, 703 etc. (the diagram is not to scale, as there is a discontinuity shown between ATM cell burst 706 and synchronization cell burst 710). In the example illustrated, bursts 706 and 715 contain cells having the same VPI and VCI (connection A) and bursts 703, 704, 712 and 713 contain cells having another VPI and VCI (connection B). One of these cells may be ATM layer synchronization cell 110.

Below cell stream 700 is illustrated cell stream 720. Cell stream 720 is the activity in real time on the downlink of the second ATM radio channel 32 and comprises physical layer synchronization cell bursts 721 and 730 marking the frames on the physical channel. These are separated by the same frame length (N cells). Bursts 726 and 735 show another independent connection on the channel (connection C). Bursts 725 and 734 show that the ATM cells of connection A are being received on this physical channel. Note that the frequency and bandwidth of this channel are the same as the frequency and bandwidth of the physical channel supporting cell stream 700. Note also that there is not necessarily any code-divided spreading of the different physical channels. The two channel are able to co-exist by virtue of careful

selection by each base station-mobile station pair of time slots that are available for that pair.

Thus, for example, connection C in cell stream **720** is established during gaps in the cell stream **700**. Connection A over cell stream **700** is also established during gaps in cell stream **700**. Synchronization cell bursts **721**, **730** in cell stream **720** are shown as coinciding with cell bursts **703**, **704** etc. because it is wholly possible that bursts **721**, **730** etc. do not interfere with the mobile station communicating over bursts **703**, **704** etc. by virtue of the location of that mobile station and its power selection.

Time lines **740** and **750** show wake-up times for mobile station **30**. Before the handoff, logic unit **520** of mobile station **30** is powering up its receiver **502** over control line **523** during time periods T1, T2, T3 and T4—that is to say only at times coinciding with bursts in the frame relevant to the mobile station **30** (in particular ATM cell bursts for the connection supported and synchronization cell bursts for the physical channel).

When a handoff conditions are met, i.e. handoff is perceived as available or a command is received from the communicating base station requiring a handoff, the logic unit **520** of the mobile station **30** powers the receiver **502** up by providing a signal over control line **523** for a longer time period T5 sufficient to encompass the arrival of synchronization cell burst **721** of cell stream **720** and ATM cell burst **725** of the connection supported. Thereafter it can power down until the next following synchronization cell burst **730** of the new base station cell stream **720**. Other arrangements can be envisaged where the mobile station extends its receiver wake-up time during the handoff and reduces it when synchronization of the cell streams is complete. At a minimum, it must remain in receive mode until synchronization cell burst **721** from the new base station is received.

Thus a method of operation of the mobile station has been described comprising the steps of powering up the receiver **502** during first time periods T1 corresponding to physical layer synchronization cells **701** arriving from the old base station and second time periods T2 corresponding to ATM cells arriving from the old base station, determining that handoff conditions are met and powering up the receiver for a third time period T5 longer than the first and second time periods. The third time period extends at least until a physical layer synchronization cell **721** is received from the new base station and preferably at least until an ATM cell **725** is received from the new base station following the physical layer synchronization cell from the new base station. After a handoff from the first base station to the second base station, the receiver is powered up during fourth time periods (T6 or T7) shorter than the third time period (T5).

Time line **760** illustrates operation of the mobile station **30** in transmission, i.e. the uplink cell stream over the R.F. interface. In transmission, during the handoff, the mobile station simultaneously transmits its uplink cells over the virtual connection to base station **13** and the virtual connection to base station **14**. This is achieved in one of two ways.

The first and preferred way is illustrated in FIG. **14** and shows that a cell **761** containing uplink data (or an uplink F5 synchronization cell) is transmitted and after a full frame period, the next cell **762** of the sequence is transmitted. These are marked as connection A' and form the connection to the old base station. As soon as possible after cell **761**, the same cell is transmitted but with the VPI and VCI appropriate to the connection to the new base station. This is shown as cell **771**, and a frame later the next subsequent cell **772** is transmitted. Thus there is duplication of the transmission of the cell payload, with different headers. Note that the locations of cells **761** and **771** are selected according to the activity on the uplink channel (which preferably has a different frequency band to the frequency band of the downlink channel but could indeed share the same frequency band). Note also that the timing of transmission of the uplink cells is selected so as not to coincide with the corresponding cells on the two downlink channels represented by cell streams **700** and **720**. This is advantageous for antenna switching and receiver sensitivity reasons.

The second way of simultaneously transmitting uplink cells over the virtual connections to the two base stations is by selecting the VCI and VPI for the new uplink connection as being the same as the VPI and VCI for the existing uplink connection and transmitting each cell only once. In this scheme, commands **77** and **78** of FIG. **7** do not require the establishment of a new connection, but command **77** merely informs the mobile station of the acceptance of the cells by the base station and command **78** is an acknowledgment. As one of the final steps of this handoff process, the VPI number can be changed to a new VPI number selected by the new base station.

FIG. **15** is a flow diagram illustrating a splicing process performed by the logic unit **520** of the mobile station **30** of FIG. **13**. In step **800**, the step in the handoff process has been reached at which duplicate cells are arriving at the mobile station **30** relating to the same communication, but arriving from different base stations in a manner the same as has been described with reference to the cell streams arriving at the BSC as illustrated in FIG. **8**. Received physical layer synchronization cells are discarded. In step **801**, cells from the new base station are stored in FIFO buffer **540**. When handoff conditions are met (step **802**), the mobile station **30** waits for the next (or first) ATM synchronization cell (similar to cell **120** in FIG. **8** but this time received over the air within one of cell bursts **725**, **734** etc.) from the new base station (step **803**). If in step **804** the ATM synchronization cell first arrives from the old base station (as in FIG. **9**), step **805** discards subsequent user data cells from the old base station and outputs to the higher layers of the protocol the user data cells from the new base station after synchronization with the new base station. Otherwise (step **810**) user data cells from the new base station are stored in FIFO buffer **540** until the next ATM synchronization cell (similar to cell **110** in FIG. **8**) is received from the old base station, in a manner similar to that shown in FIG. **10**. Eventually (step **812**) the ATM synchronization cells are discarded and the resulting continuous spliced cell stream is passed to the upper layers of the protocol and eventually to an application layer where the data is output to the user through operator interface **533** as voice or message text or video or in whatever form the application dictates or it is passed on to some other device over interface **535**.

The splicing process can be modified to include synchronization so that it supports real-time service categories. Each node in the ATM virtual connection, the base station and the BSC(s) are required in the standard ATM architecture to determine the maximum CDV that it will insert in the connection (its CDV allocation). This requirement is extended to also require a CDV allocation for the synchronization process, to be included in the CDV allocation of the BSC or mobile station in which the synchronization process resides. Further, the standardized ATM connection control architecture allows the BSC to determine the largest cumulative CDV that could be inserted by those nodes upstream of itself.

FIG. **16** and the following description describes further details of the splicing process performed in the logic unit

520 (or the processor 530) in the mobile station 30. Similar processing is performed in the BSC 11 (or 12).

For real time service categories, the logic unit 520 and the processor 530 between them control the rate R at which ATM cells are transferred across the interface 535. The rate R is ordinarily determined at connection establishment time using information contained in the standard connection control signaling messages. If ATM cells arrive at the logic unit at a rate faster than R, then the cells are stored in FIFO 540 (or in RAM 531) until they are able to be consumed at the interface 535.

Referring to FIG. 16, the approximate differential delay D between the communication from the old BS and the communication from the new BS is measured in step 900 by determining the time between the arrival of a sync cell $sync_{m-1}$ from the old BS and the corresponding arrival of $sync_{m-1}$ from the new BS. If (step 902) the absolute value of D is less than a predetermined delay value, then the splicing process proceeds in step 904 as shown in FIG. 9 or FIG. 10. No further delay compensation is needed.

If step 906 determines that synchronization cell synchm−1 from the old base station arrives before synchronization cell synchm−1 arrives from the new base station, then in step 908 the synchronization process calculates a compensating FIFO depth F for FIFO buffer 540, such that F is a number of cells that need to be stored to allow the handover to take place without exceeding the CDV allocation for the synchronization process. Step 910 then calculates a rate reduction factor $r<1$, such that R^*r allows F cells to accumulate in the FIFO in k blocks. The value of r is further determined such that reducing the service rate in step 912 at interface 535 to R^*r will not cause the CDV allocation to be exceeded. Except when D is exceptionally large, r will be equal to 1. When the FIFO contains F cells (step 914), then splicing can proceed as illustrated in FIG. 9 (step 916). At the same time (step 918), the service rate at interface 535 is increased to R and the splicing process is concluded (step 920).

If, in step 906, synchronization cell synchm−1 from the old base station arrives after synchronization cell synchm−1 arrives from the new base station, then synchronization is performed as illustrated in FIG. 10 (step 930). The clustered cells received from the new base station, cells 154, 155, 156, are stored in the FIFO 540. A rate increase factor r' is calculated in step 932 such that increasing the service rate at the interface 535 to r'^*R will not cause the CDV allocation for the synchronization process to be exceeded. The service rate at the interface 535 is then increased in step 934 to r'^*R. When the FIFO becomes empty (or nearly empty) as determined by step 936, the service rate at interface 535 is reduced again in step 938 to R and the splicing process is concluded (step 940).

Thus a handoff process has been described which comprises combining first and second cell streams in a remote station (mobile station) of a radio communications system, comprising: receiving a first cell stream 700 from a first base station 13, the first cell stream including first synchronization cells (preferably ATM synchronization cells e.g. cell 110, but alternatively physical layer synchronization cells e.g. cell 701); receiving a second cell stream 720 from a second base station 14, the second cell stream including second synchronization cells (preferably ATM synchronization cells e.g. cell 120, but alternatively physical layer synchronization cells e.g. cell 721); outputting the first cell stream until a first synchronization cell is received; receiving a second synchronization cell; and outputting the second cell stream following the second synchronization cell.

The handoff process has significant advantages over soft handoff processes in prior art systems such as CDMA systems, especially where data is conveyed, because it does not rely on correlation of the data content (e.g. voice correlation) but allows seamless splicing of the ATM cells carrying the data and avoids or minimizes data loss or duplication. It also has advantages in systems carrying data where service rate is important, such as video data, as it allows for smooth continuous flow control of the data without jitter.

Modifications of the arrangements described can be made within the scope of the invention. For example it has been described how sequence numbers are provided for individual cells and how sequence numbers are provided in ATM synchronization cells (F5 cells). As an alternative one or other of these sequence numbers can be omitted. Also it has been described how synchronization cell bursts (F3 cells) are provided in the physical layer and ATM synchronization cells (F5 cells) are provided in the ATM layer. In an alternative embodiment only one of these sets of synchronization cells are used.

What is claimed is:

1. A method of operation of a radio communications system comprising a remote station, a first base station and at least a second base station, having an ATM communication connection established between the remote station and the first base station with at least a first virtual connection identifier, the method comprising the steps of:

determining that handoff conditions are met for a handoff to the second base station;

selecting a second virtual path identifier and a second virtual connection identifier for a connection between the second base station and the remote station; and

wherein the first base station is provided with a sub-group of virtual path identifiers for use in communications with the remote station and the second base station is provided with a second sub-group of virtual path identifiers for use in communications with the remote station, which is mutually exclusive to the first sub-group of virtual path identifiers, and the second virtual path identifier is selected from the second sub-group.

2. The method of claim 1, wherein the step of selecting the second virtual connection identifier comprises selecting at least temporarily the first virtual connection identifier as the second virtual connection identifier, at least for ATM communications from the remote station to the second base station.

3. The method of claim 2 comprising changing at least one of a virtual path identifier and a corresponding virtual circuit identifier at least for ATM communications from the remote station to the second base station to a new value.

4. The method of claim 3, wherein the virtual path identifier is changed and the corresponding virtual circuit identifier is not changed.

* * * * *

US006591150B1

(12) United States Patent
Shirota

(10) **Patent No.: US 6,591,150 B1**
(45) **Date of Patent: Jul. 8, 2003**

(54) **REDUNDANT MONITORING CONTROL SYSTEM, MONITORING CONTROL APPARATUS THEREFOR AND MONITORED CONTROL APPARATUS**

(75) Inventor: **Masahiko Shirota**, Kawasaki (JP)

(73) Assignee: **Fujitsu Limited**, Kawasaki (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 361 days.

(21) Appl. No.: **09/625,463**

(22) Filed: **Jul. 25, 2000**

(30) **Foreign Application Priority Data**

Sep. 3, 1999 (JP) 11-250040

(51) **Int. Cl.**[7] **G05B 9/02**

(52) **U.S. Cl.** **700/82**; 700/3; 714/11; 340/3.1

(58) **Field of Search** 700/82, 79, 2–3; 714/11; 340/3.1–3.2; 712/31; 318/563–565

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,008,805 A	*	4/1991	Fiebig et al.	700/79
5,086,384 A	*	2/1992	Fukada	700/82
5,202,822 A	*	4/1993	McLaughlin et al.	700/82
5,751,220 A	*	5/1998	Ghaffari	340/825.21
5,777,874 A	*	7/1998	Flood et al.	700/82
6,272,386 B1	*	8/2001	McLaughlin et al.	700/82

FOREIGN PATENT DOCUMENTS

JP	3-71346	3/1991	G06F/11/30
JP	8-265319	10/1996	
JP	10-150457	6/1998	H04L/12/42

* cited by examiner

Primary Examiner—Emanuel Todd Voeltz
Assistant Examiner—Crystal J. Barnes
(74) *Attorney, Agent, or Firm*—Katten Muchin Zavis Rosenman

(57) **ABSTRACT**

A redundant monitoring control system includes at least one monitored control apparatus forming a communication network, and a plurality of monitoring control apparatuses monitoring and controlling the monitored control apparatus. The monitored control apparatus switches a monitoring and control of the monitored control apparatus by a monitoring control apparatus of a working system to a monitoring control apparatus of a backup system in response to a disconnection from the monitoring control apparatus of the working system which is detected when the monitoring control apparatus of the working system fails. The monitoring control apparatus of the backup system recognizes a control operation carried out by the monitoring control apparatus of the working system until the switching, and carries out a remainder of the recognized control operation with respect to the monitored control apparatus.

5 Claims, 17 Drawing Sheets

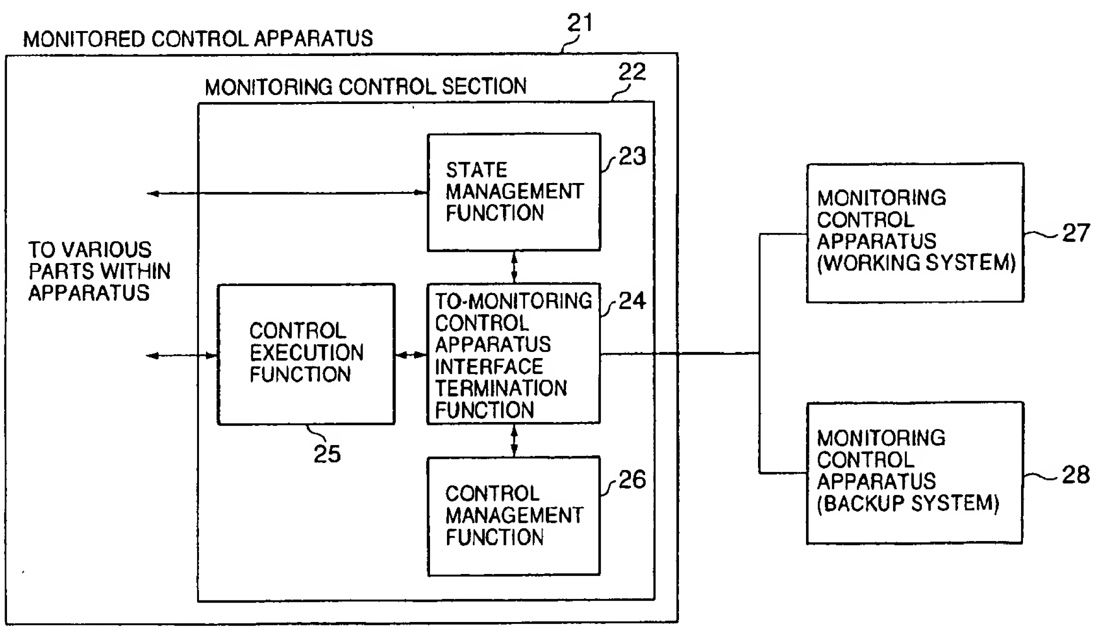


FIG. 1

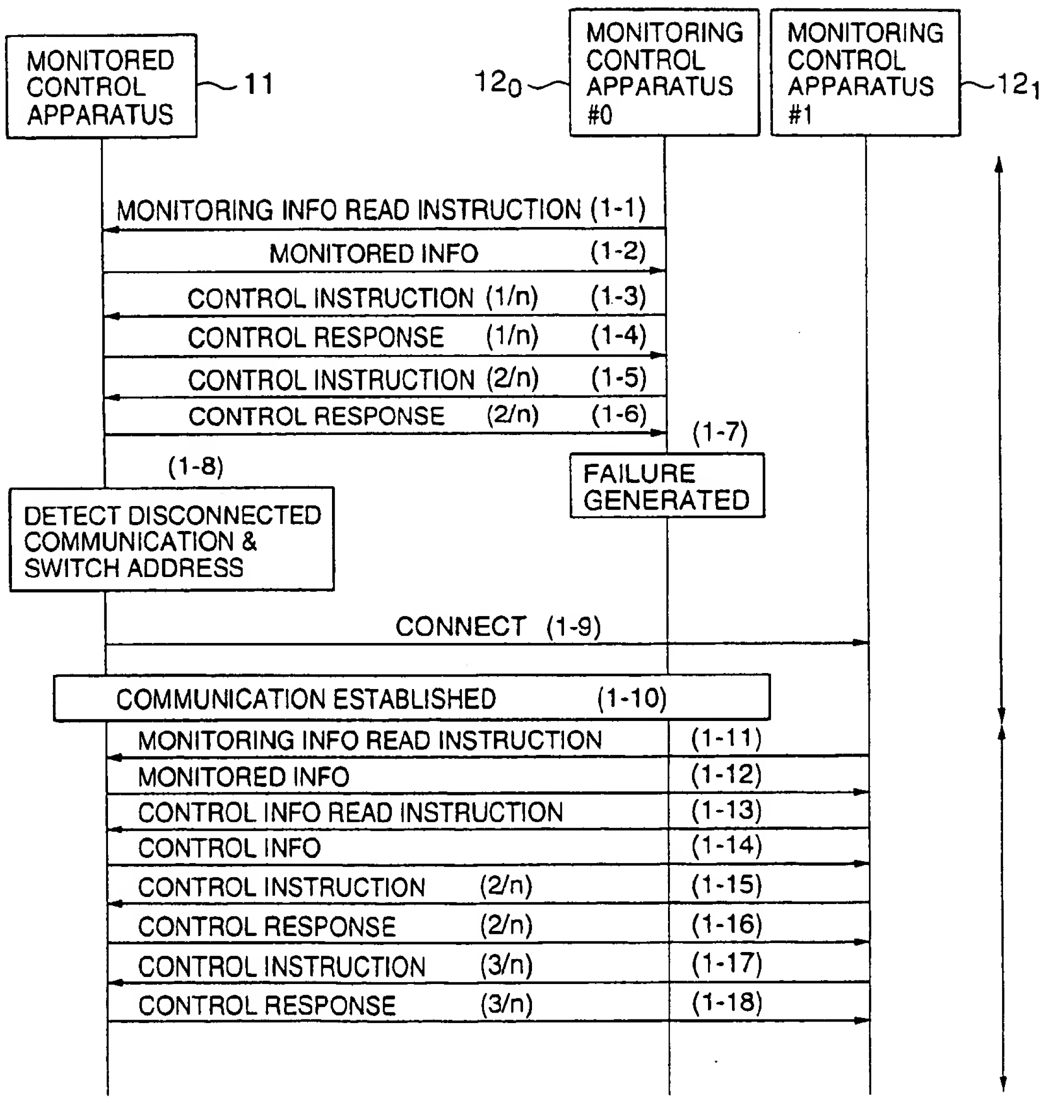

MONITORED CONTROL APPARATUS
11
12_0
MONITORING CONTROL APPARATUS #0
MONITORING CONTROL APPARATUS #1
12_1
MONITORING INFO READ INSTRUCTION (1-1)
MONITORED INFO (1-2)
CONTROL INSTRUCTION (1/n) (1-3)
CONTROL RESPONSE (1/n) (1-4)
CONTROL INSTRUCTION (2/n) (1-5)
CONTROL RESPONSE (2/n) (1-6)
(1-7)
FAILURE GENERATED
(1-8)
DETECT DISCONNECTED COMMUNICATION & SWITCH ADDRESS
CONNECT (1-9)
COMMUNICATION ESTABLISHED (1-10)
MONITORING INFO READ INSTRUCTION (1-11)
MONITORED INFO (1-12)
CONTROL INFO READ INSTRUCTION (1-13)
CONTROL INFO (1-14)
CONTROL INSTRUCTION (2/n) (1-15)
CONTROL RESPONSE (2/n) (1-16)
CONTROL INSTRUCTION (3/n) (1-17)
CONTROL RESPONSE (3/n) (1-18)

FIG. 2

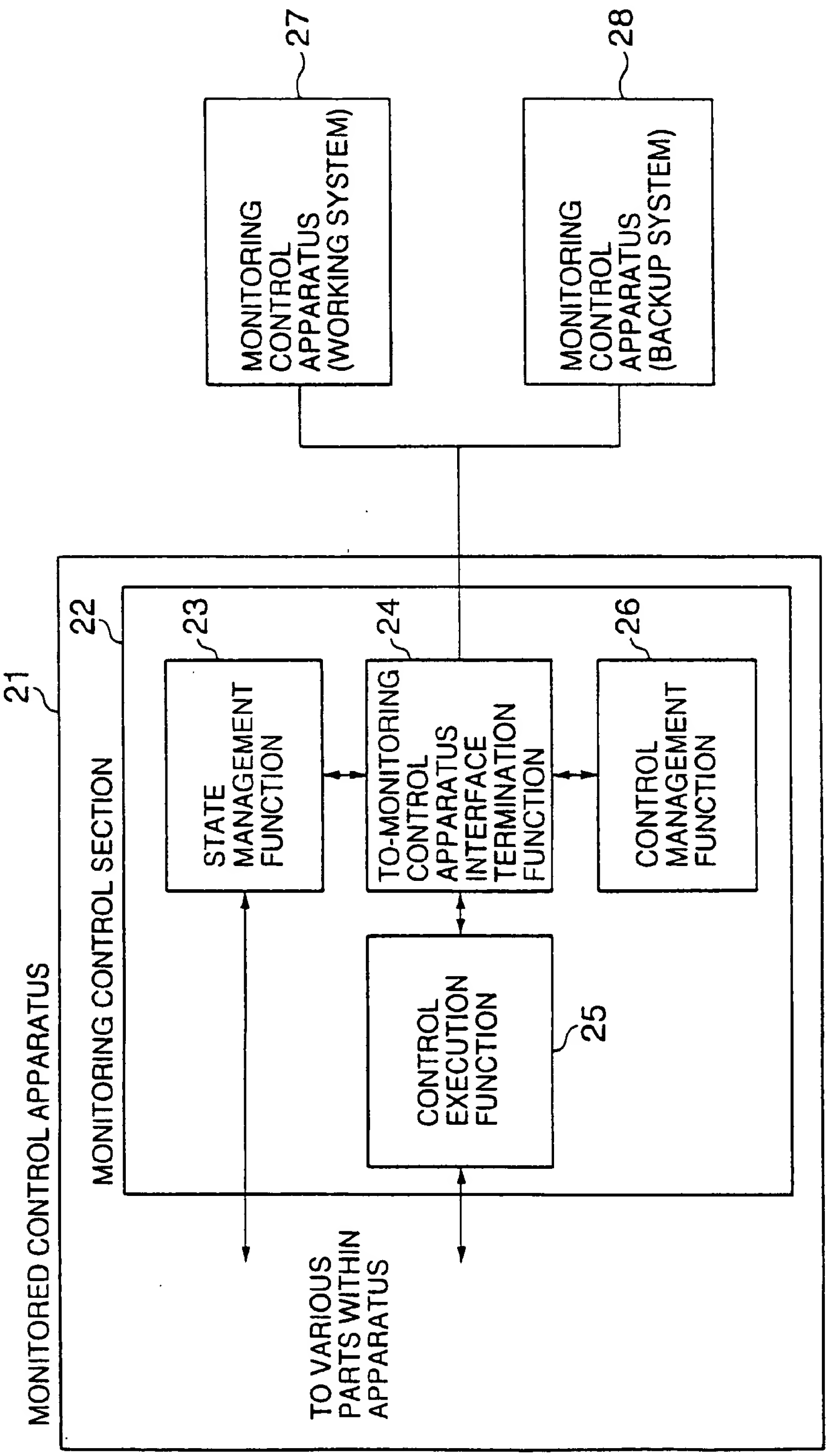

27
MONITORING CONTROL APPARATUS (WORKING SYSTEM)
28
MONITORING CONTROL APPARATUS (BACKUP SYSTEM)
21
MONITORED CONTROL APPARATUS
22
MONITORING CONTROL SECTION
23
STATE MANAGEMENT FUNCTION
24
TO-MONITORING CONTROL APPARATUS INTERFACE TERMINATION FUNCTION
26
CONTROL MANAGEMENT FUNCTION
25
CONTROL EXECUTION FUNCTION
TO VARIOUS PARTS WITHIN APPARATUS

FIG. 3

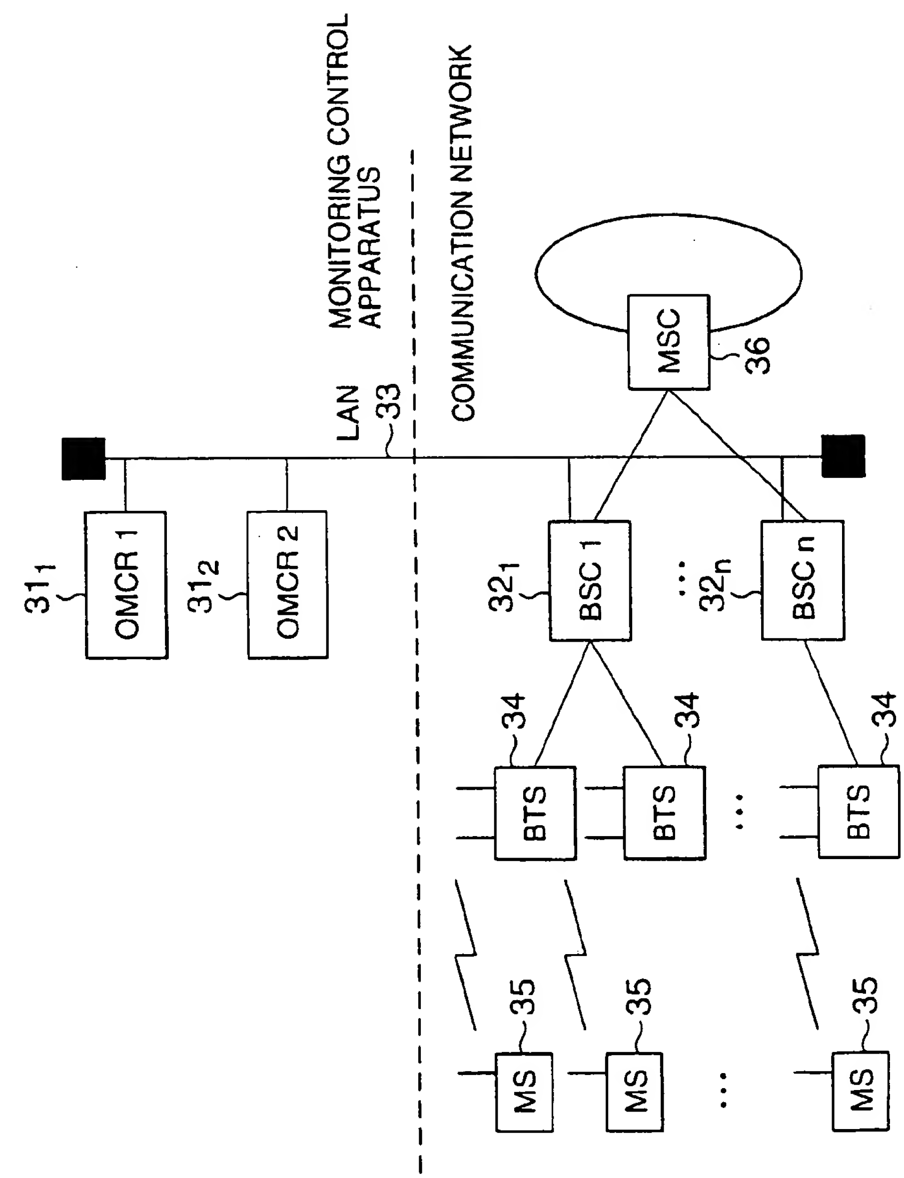

MONITORING CONTROL APPARATUS
COMMUNICATION NETWORK
LAN
33
MSC
36
OMCR 1
31_1
OMCR 2
31_2
BSC 1
32_1
BSC n
32_n
BTS
34
MS
35

FIG. 4

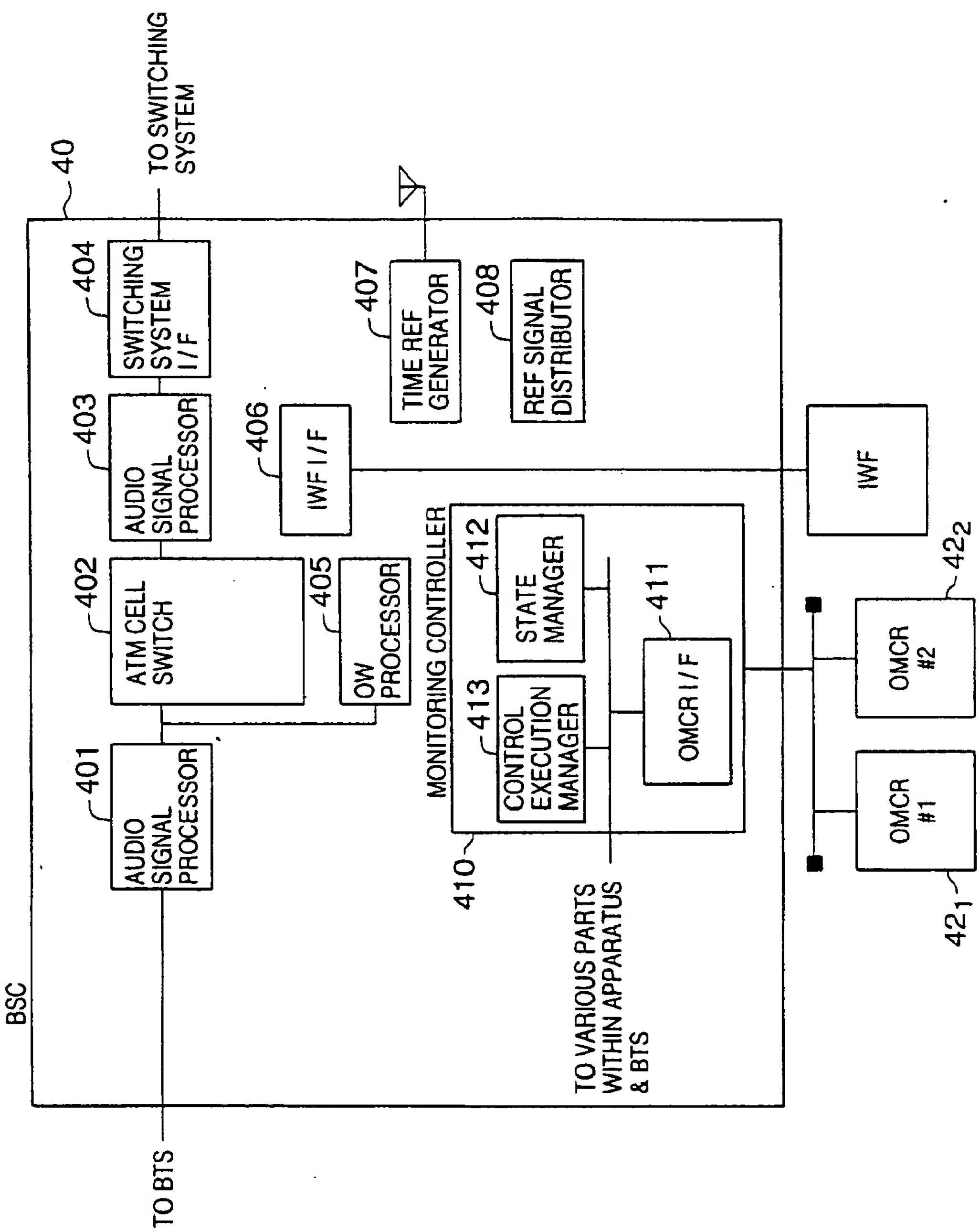

TO SWITCHING SYSTEM
40
BSC
404
SWITCHING SYSTEM I / F
403
AUDIO SIGNAL PROCESSOR
402
ATM CELL SWITCH
401
AUDIO SIGNAL PROCESSOR
405
OW PROCESSOR
406
IWF I / F
407
TIME REF GENERATOR
408
REF SIGNAL DISTRIBUTOR
MONITORING CONTROLLER
412
STATE MANAGER
413
CONTROL EXECUTION MANAGER
411
OMCR I / F
410
TO VARIOUS PARTS WITHIN APPARATUS & BTS
TO BTS
IWF
OMCR #2
42₂
OMCR #1
42₁

FIG. 5

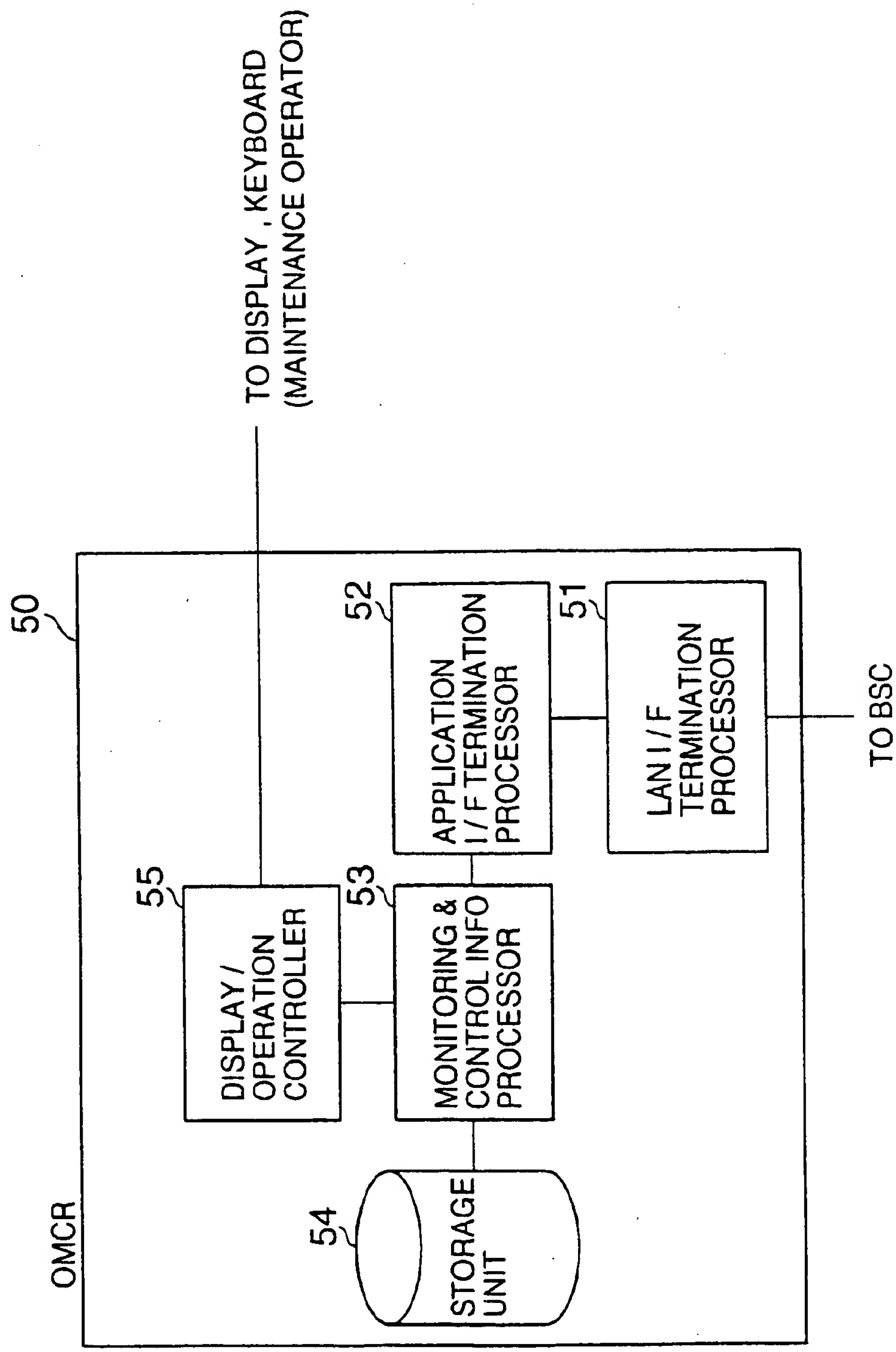
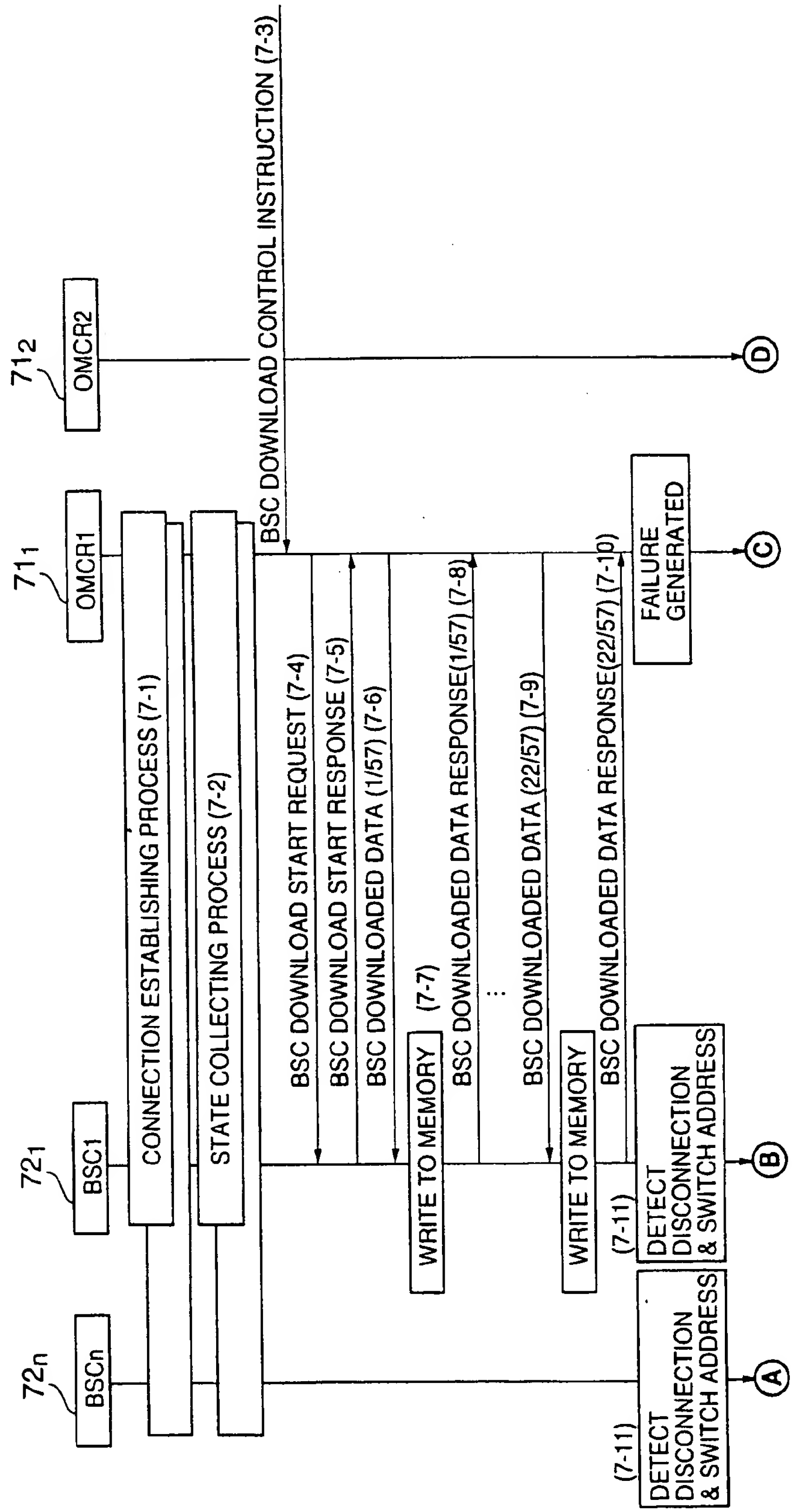

TO DISPLAY, KEYBOARD
(MAINTENANCE OPERATOR)
50
OMCR
55
DISPLAY / OPERATION CONTROLLER
53
MONITORING & CONTROL INFO PROCESSOR
52
APPLICATION I / F TERMINATION PROCESSOR
51
LAN I / F TERMINATION PROCESSOR
TO BSC
54
STORAGE UNIT

FIG. 6

APPARATUS NAME	OWN IP ADDRESS	IP ADDRESS OF EACH COMMUNICATION DESTINATION
OMCR1	IPADDR_OMCR1	IPADDR_BSC1,⋯,IPADDR_BSCn
OMCR2	IPADDR_OMCR2	IPADDR_BSC1,⋯,IPADDR_BSCn
BSC1	IPADDR_BSC1	#1:IPADDR_OMCR1,#2:IPADDR_OMCR2
⋮	⋮	⋮
BSCn	IPADDR_BSCn	#1:IPADDR_OMCR1,#2:IPADDR_OMCR2

FIG. 7



71_2
OMCR2
71_1
OMCR1
72_1
BSC1
72_n
BSCn
CONNECTION ESTABLISHING PROCESS (7-1)
STATE COLLECTING PROCESS (7-2)
BSC DOWNLOAD CONTROL INSTRUCTION (7-3)
BSC DOWNLOAD START REQUEST (7-4)
BSC DOWNLOAD START RESPONSE (7-5)
BSC DOWNLOADED DATA (1/57) (7-6)
WRITE TO MEMORY (7-7)
BSC DOWNLOADED DATA RESPONSE(1/57) (7-8)
...
BSC DOWNLOADED DATA (22/57) (7-9)
WRITE TO MEMORY
BSC DOWNLOADED DATA RESPONSE(22/57) (7-10)
FAILURE GENERATED
(7-11) DETECT DISCONNECTION & SWITCH ADDRESS
(7-11) DETECT DISCONNECTION & SWITCH ADDRESS
A
B
C
D

FIG. 8

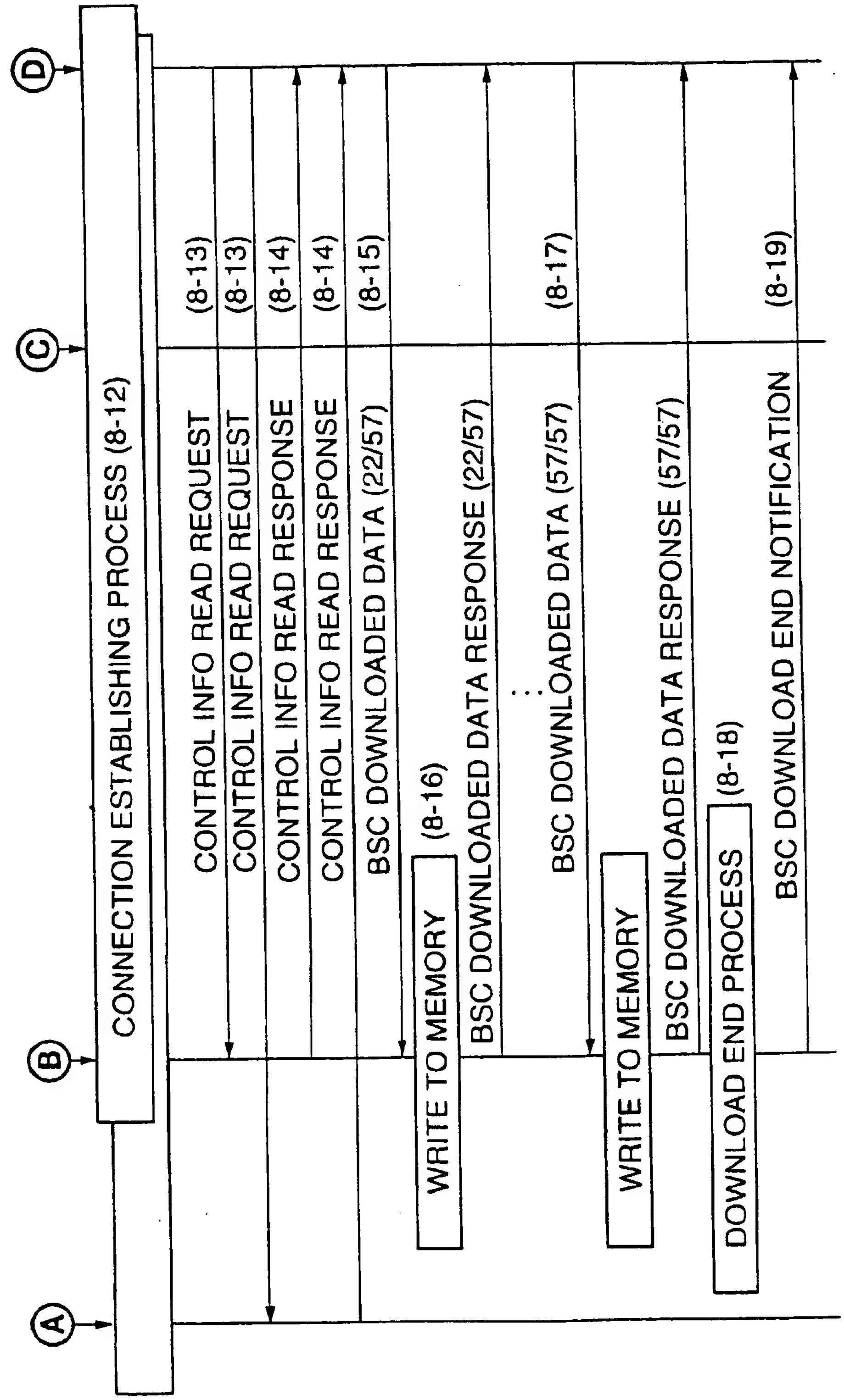
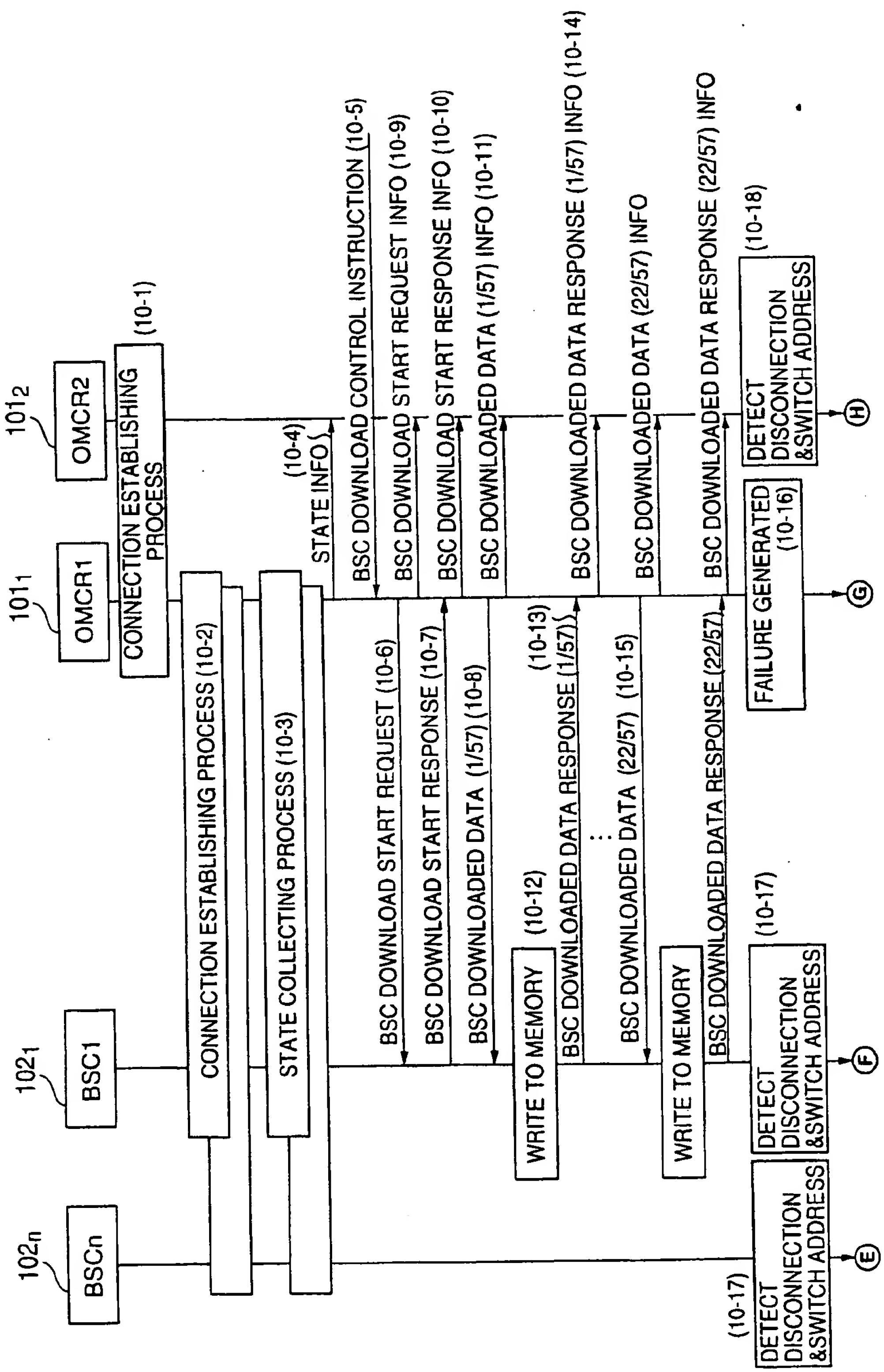

A
B
C
D
CONNECTION ESTABLISHING PROCESS (8-12)
CONTROL INFO READ REQUEST
(8-13)
CONTROL INFO READ REQUEST
(8-13)
CONTROL INFO READ RESPONSE
(8-14)
CONTROL INFO READ RESPONSE
(8-14)
BSC DOWNLOADED DATA (22/57)
(8-15)
WRITE TO MEMORY
(8-16)
BSC DOWNLOADED DATA RESPONSE (22/57)
BSC DOWNLOADED DATA (57/57)
(8-17)
WRITE TO MEMORY
BSC DOWNLOADED DATA RESPONSE (57/57)
DOWNLOAD END PROCESS
(8-18)
BSC DOWNLOAD END NOTIFICATION
(8-19)

FIG. 9

APPARATUS NAME	OWN IP ADDRESS	IP ADDRESS OF EACH COMMUNICATION DESTINATION
OMCR1	IPADDR_OMCR1	IPADDR_OMCR2,IPADDR_BSC1,…,IPADDR_BSCn
OMCR2	IPADDR_OMCR2	IPADDR_OMCR1,IPADDR_BSC1,…,IPADDR_BSCn
BSC1	IPADDR_BSC1	#1:IPADDR_OMCR1,#2:IPADDR_OMCR2
…	…	…
BSCn	IPADDR_BSCn	#1:IPADDR_OMCR1,#2:IPADDR_OMCR2

FIG. 10



101_1
OMCR1
101_2
OMCR2
102_1
BSC1
102_n
BSCn
CONNECTION ESTABLISHING PROCESS (10-1)
CONNECTION ESTABLISHING PROCESS (10-2)
STATE COLLECTING PROCESS (10-3)
STATE INFO (10-4)
BSC DOWNLOAD CONTROL INSTRUCTION (10-5)
BSC DOWNLOAD START REQUEST (10-6)
BSC DOWNLOAD START RESPONSE (10-7)
BSC DOWNLOADED DATA (1/57) (10-8)
BSC DOWNLOAD START REQUEST INFO (10-9)
BSC DOWNLOAD START RESPONSE INFO (10-10)
BSC DOWNLOADED DATA (1/57) INFO (10-11)
WRITE TO MEMORY (10-12)
BSC DOWNLOADED DATA RESPONSE (1/57) (10-13)
BSC DOWNLOADED DATA RESPONSE (1/57) INFO (10-14)
BSC DOWNLOADED DATA (22/57) (10-15)
BSC DOWNLOADED DATA (22/57) INFO
WRITE TO MEMORY
BSC DOWNLOADED DATA RESPONSE (22/57)
BSC DOWNLOADED DATA RESPONSE (22/57) INFO
FAILURE GENERATED (10-16)
DETECT DISCONNECTION &SWITCH ADDRESS (10-17)
DETECT DISCONNECTION &SWITCH ADDRESS (10-17)
DETECT DISCONNECTION &SWITCH ADDRESS (10-18)
E
F
G
H

FIG. 11

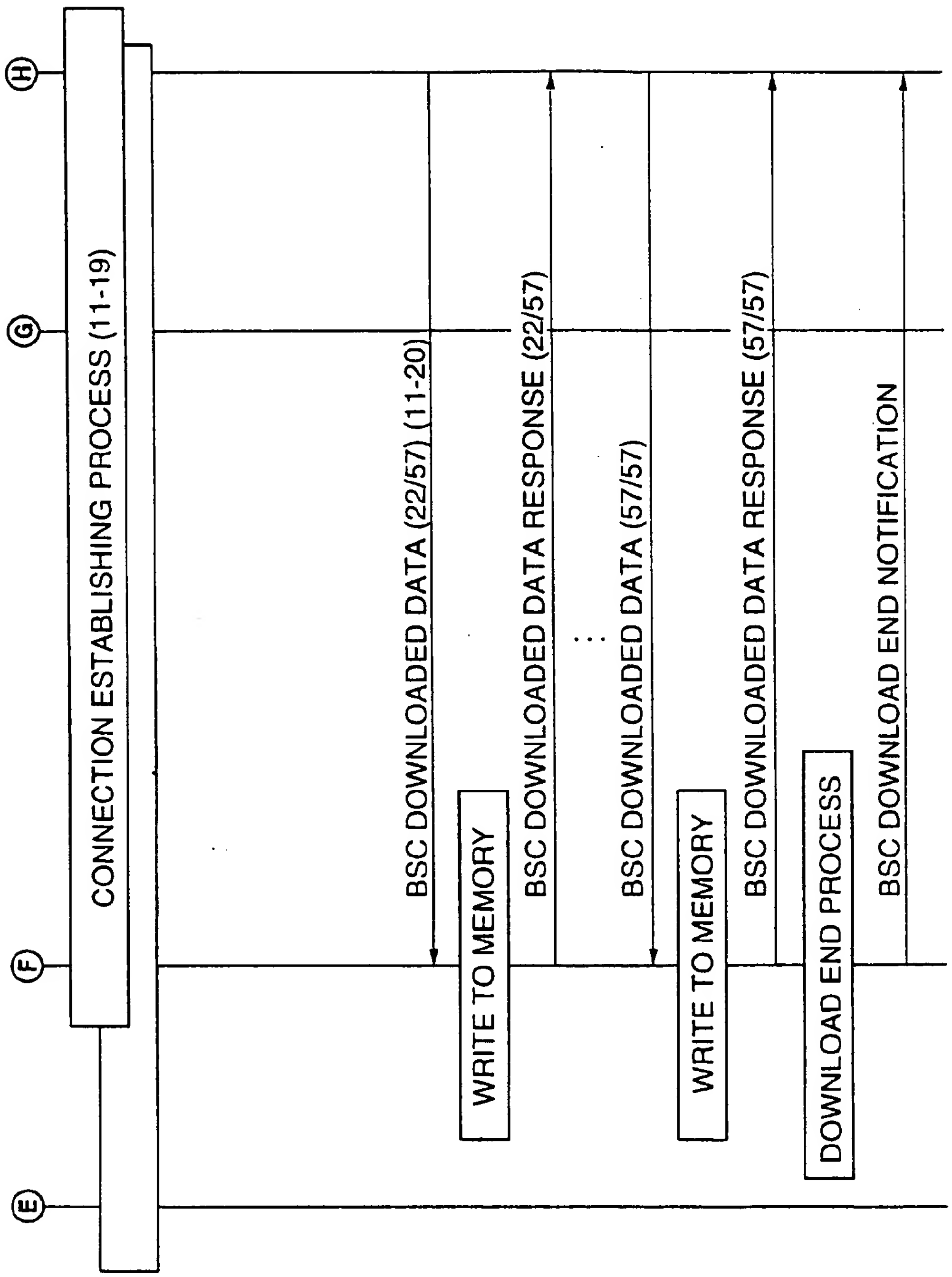
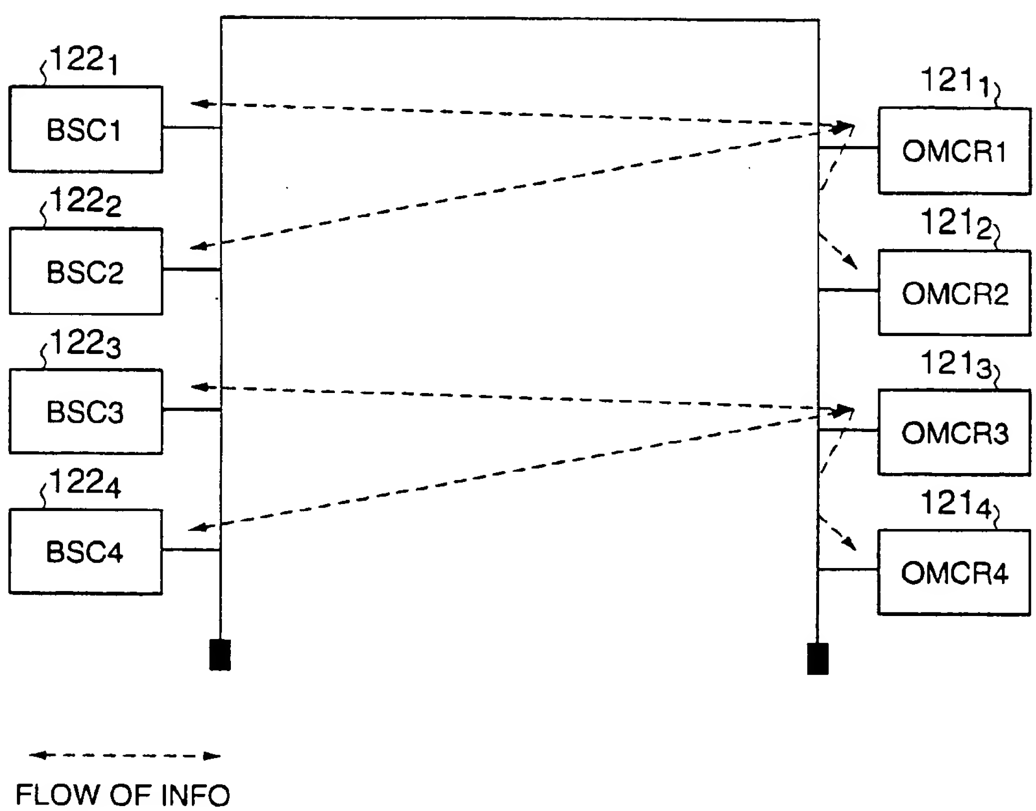
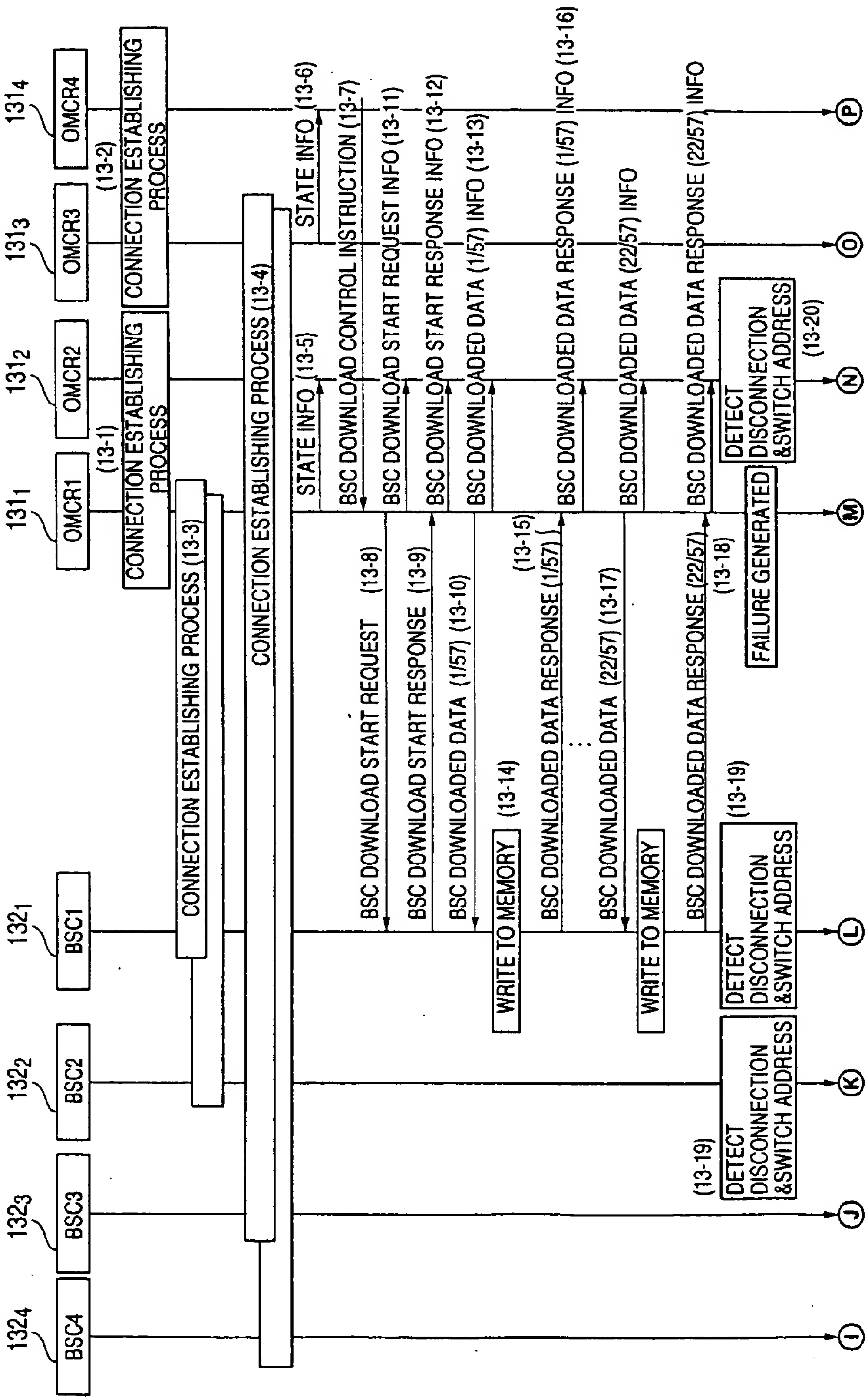

E
F
G
H
CONNECTION ESTABLISHING PROCESS (11-19)
BSC DOWNLOADED DATA (22/57) (11-20)
WRITE TO MEMORY
BSC DOWNLOADED DATA RESPONSE (22/57)
...
BSC DOWNLOADED DATA (57/57)
WRITE TO MEMORY
BSC DOWNLOADED DATA RESPONSE (57/57)
DOWNLOAD END PROCESS
BSC DOWNLOAD END NOTIFICATION

FIG. 12



122_1
BSC1
122_2
BSC2
122_3
BSC3
122_4
BSC4
121_1
OMCR1
121_2
OMCR2
121_3
OMCR3
121_4
OMCR4
FLOW OF INFO

FIG. 13



131₁
OMCR1
131₂
OMCR2
131₃
OMCR3
131₄
OMCR4
132₁
BSC1
132₂
BSC2
132₃
BSC3
132₄
BSC4
(13-1)
CONNECTION ESTABLISHING PROCESS
(13-2)
CONNECTION ESTABLISHING PROCESS
CONNECTION ESTABLISHING PROCESS (13-3)
CONNECTION ESTABLISHING PROCESS (13-4)
STATE INFO (13-5)
STATE INFO (13-6)
BSC DOWNLOAD CONTROL INSTRUCTION (13-7)
BSC DOWNLOAD START REQUEST (13-8)
BSC DOWNLOAD START RESPONSE (13-9)
BSC DOWNLOADED DATA (1/57) (13-10)
BSC DOWNLOAD START REQUEST INFO (13-11)
BSC DOWNLOAD START RESPONSE INFO (13-12)
BSC DOWNLOADED DATA (1/57) INFO (13-13)
WRITE TO MEMORY (13-14)
BSC DOWNLOADED DATA RESPONSE (1/57) (13-15)
BSC DOWNLOADED DATA RESPONSE (1/57) INFO (13-16)
BSC DOWNLOADED DATA (22/57) (13-17)
WRITE TO MEMORY
BSC DOWNLOADED DATA (22/57) INFO
BSC DOWNLOADED DATA RESPONSE (22/57) (13-18)
BSC DOWNLOADED DATA RESPONSE (22/57) INFO
FAILURE GENERATED
(13-19)
DETECT DISCONNECTION &SWITCH ADDRESS
(13-19)
DETECT DISCONNECTION &SWITCH ADDRESS
DETECT DISCONNECTION &SWITCH ADDRESS
(13-20)
DETECT DISCONNECTION &SWITCH ADDRESS
P
O
N
M
L
K
J
I

FIG. 14

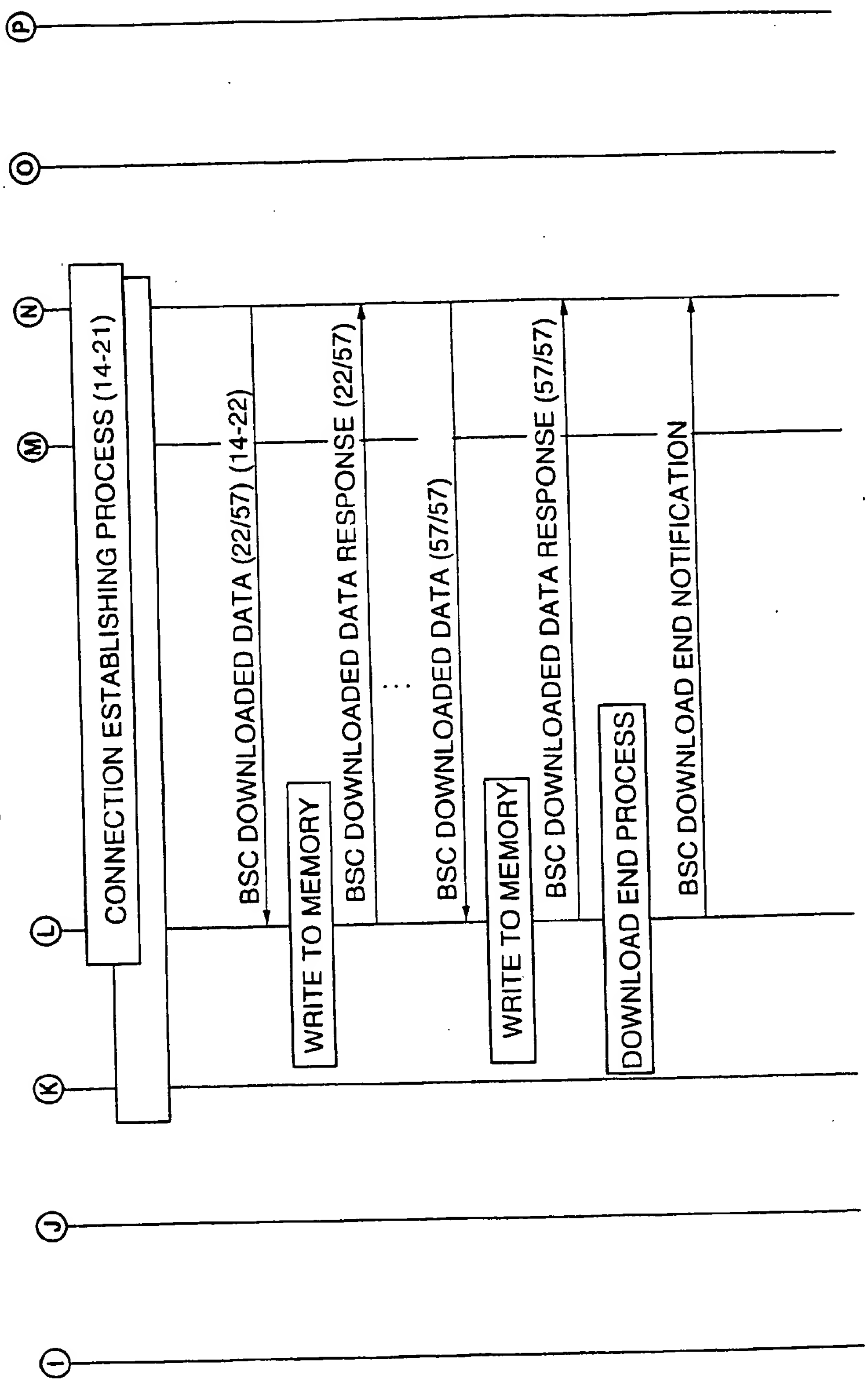

P
O
N
M
L
K
J
I
CONNECTION ESTABLISHING PROCESS (14-21)
BSC DOWNLOADED DATA (22/57) (14-22)
WRITE TO MEMORY
BSC DOWNLOADED DATA RESPONSE (22/57)
...
BSC DOWNLOADED DATA (57/57)
WRITE TO MEMORY
BSC DOWNLOADED DATA RESPONSE (57/57)
DOWNLOAD END PROCESS
BSC DOWNLOAD END NOTIFICATION

FIG. 15

STATE	GENERATED EVENT	OMCR1	OMCR2	OMCR3	OMCR4
1	INITIAL STATE	BSC1,BSC2	(BACKUP SYSTEM FOR OMCR1)	BSC3,BSC4	(BACKUP SYSTEM FOR OMCR3)
2	FAILURE GENERATED IN OMCR1	× DURING FAILURE	BSC1,BSC2	BSC3,BSC4 (BACKUP SYSTEM FOR OMCR2)	(BACKUP SYSTEM FOR OMCR3)
3	FAILURE GENERATED IN OMCR2	× DURING FAILURE	× DURING FAILURE	BSC1,BSC2 BSC3,BSC4	(BACKUP SYSTEM FOR OMCR3)
4	FAILURE GENERATED IN OMCR3	× DURING FAILURE	× DURING FAILURE	× DURING FAILURE	BSC1,BSC2 BSC3,BSC4

FIG. 16

APPARATUS NAME	OWN IP ADDRESS	IP ADDRESS OF EACH COMMUNICATION DESTINATION ("IPADDR_" OMITTED)
OMCR1	IPADDR_OMCR1	OMCR2,4,BSC1,2,3,4 (ITEMS OF USE) [FOR WHEN OMCR3 IS NORMAL (MONITOR & CONTROL BSC1,2)] OMCR2,BSC1,2 [FOR WHEN OMCR3 FAILS (OPERATE AS BACKUP SYSTEM FOR OMCR4)] OMCR2,4,BSC1,2 [FOR WHEN OMCR3,4 FAILS (MONITOR & CONTROL BSC1,2,3,4)] OMCR2,BSC1,2,3,4
OMCR2	IPADDR_OMCR2	OMCR1,3,BSC1,2,3,4 (ITEMS OF USE) [FOR WHEN OMCR1 IS NORMAL (OPERATE AS BACKUP SYSTEM FOR OMCR1)] OMCR1 [FOR WHEN OMCR1 FAILS (MONITOR & CONTROL BSC1,2)] OMCR3,BSC1,2 [FOR WHEN OMCR1,3,4 FAILS] BSC1,2,3,4
OMCR3	IPADDR_OMCR3	OMCR2,4,BSC1,2,3,4 (ITEMS OF USE) [FOR WHEN OMCR1 IS NORMAL (MONITOR & CONTROL BSC3,4)] OMCR4,BSC3,4 [FOR WHEN OMCR1 FAILS (OPERATE AS BACKUP SYSTEM FOR OMCR2)] OMCR2,4,BSC3,4 [FOR WHEN OMCR1,2 FAILS (MONITOR & CONTROL BSC1,2,3,4)] OMCR4,BSC1,2,3,4
OMCR4	IPADDR_OMCR4	OMCR1,3,BSC1,2,3,4 (ITEMS OF USE) [FOR WHEN OMCR3 IS NORMAL (OPERATE AS BACKUP SYSTEM FOR OMCR3)] OMCR3 [FOR WHEN OMCR3 FAILS (MONITOR & CONTROL BSC3,4)] OMCR1,BSC3,4 [FOR WHEN OMCR1,2,3 FAILS] BSC1,2,3,4

FIG. 17

APPARATUS NAME	OWN IP ADDRESS	IP ADDRESS OF EACH COMMUNICATION DESTINATION ("IPADDR_" OMITTED)
BSC1	IPADDR_BSC1	OMCR1,2,3,4 (ITEMS OF USE) [FOR WHEN OMCR1 IS NORMAL (CONNECT TO OMCR1)] OMCR1 [FOR WHEN OMCR1 FAILS (CONNECT TO OMCR2)] OMCR2 [FOR WHEN OMCR1,2 FAILS (CONNECT TO OMCR3)] OMCR3 [FOR WHEN OMCR1,2,3 FAILS (CONNECT TO OMCR4)] OMCR4
BSC2	IPADDR_BSC2	OMCR1,2,3,4 (ITEMS OF USE) [FOR WHEN OMCR1 IS NORMAL (CONNECT TO OMCR1)] OMCR1 [FOR WHEN OMCR1 FAILS (CONNECT TO OMCR2)] OMCR2 [FOR WHEN OMCR1,2 FAILS (CONNECT TO OMCR3)] OMCR3 [FOR WHEN OMCR1,2,3 FAILS (CONNECT TO OMCR4)] OMCR4
BSC3	IPADDR_BSC3	OMCR1,2,3,4 (ITEMS OF USE) [FOR WHEN OMCR3 IS NORMAL (CONNECT TO OMCR3)] OMCR3 [FOR WHEN OMCR3 FAILS (CONNECT TO OMCR4)] OMCR4 [FOR WHEN OMCR3,4 FAILS (CONNECT TO OMCR1)] OMCR1 [FOR WHEN OMCR1,3,4 FAILS (CONNECT TO OMCR2)] OMCR2
BSC4	IPADDR_BSC4	OMCR1,2,3,4 (ITEMS OF USE) [FOR WHEN OMCR3 IS NORMAL (CONNECT TO OMCR3)] OMCR3 [FOR WHEN OMCR3 FAILS (CONNECT TO OMCR4)] OMCR4 [FOR WHEN OMCR3,4 FAILS (CONNECT TO OMCR1)] OMCR1 [FOR WHEN OMCR1,3,4 FAILS (CONNECT TO OMCR2)] OMCR2

REDUNDANT MONITORING CONTROL SYSTEM, MONITORING CONTROL APPARATUS THEREFOR AND MONITORED CONTROL APPARATUS

BACKGROUND OF THE INVENTION

This application claims the benefit of a Japanese Patent Application No. 11-250040 filed Sep. 3, 1999, in the Japanese Patent Office, the disclosure of which is hereby incorporated by reference.

1. Field of the Invention

The present invention generally relates to redundant monitoring control systems, monitoring control apparatuses therefor and monitored control apparatuses, and more particularly to a redundant monitoring control system which carries out remote monitoring and control of monitored control apparatuses such as communication apparatuses which form a communication network, by switching a working one of monitoring control apparatuses which form a redundant structure. The present invention also relates to a monitoring control apparatus which includes a means of switching the monitoring control to another monitoring control apparatus, and to a monitored control apparatus which is monitored controlled by such a monitoring control apparatus.

Communication systems form a basis of society, and if a failure is generated in a communication network to interrupt a communication service, damages caused thereby spread over a wide range. For this reason, there are demands to minimize the failure in the communication systems.

In order to cope with such demands, a monitoring control apparatus is provided to constantly monitor the state of the communication network. The monitoring control apparatus detects the generation of the failure in the communication network at an early stage, and takes appropriate measures against the detected failure, so as to prevent a situation where a serious failure such as the interruption of the communication service is generated.

However, if the monitoring control apparatus itself fails, it becomes impossible to monitor the state of the communication network. Hence, in order to enable constant monitoring and control of the communication even when the monitoring control apparatus itself fails, a plurality of monitoring control apparatuses are provided to carry out the monitoring and control of the communication network by use of a redundant structure.

According to the redundant structure which uses the plurality of monitoring control apparatuses, the working monitoring control apparatus which actually monitors and controls the communication network is switched to another backup monitoring apparatus which operates normally if the working monitoring control apparatus fails, so that after the switching, the communication network is similarly monitored and controlled by the backup monitoring control apparatus.

2. Description of the Related Art

According to the conventional monitoring and control system employing the redundant structure, an operator of the monitoring control apparatus manually switches from the working monitoring control apparatus to the backup monitoring control apparatus when a failure is generated in the working monitoring control apparatus. That is, the operator manually switches the connection from the working monitoring control apparatus to the backup monitoring control apparatus, resumes the monitoring and control of the communication network by the backup monitoring control apparatus, and continues the monitoring and control operation.

On the other hand, instead of employing the redundant structure which uses the plurality of monitoring and control apparatuses, it is possible to construct the monitoring control apparatus by a high-reliability computer which can internally realize a redundant function. But in this case, it is necessary to use an expensive and special computer, which makes the hardware of the monitoring control apparatus itself expensive. As a result, the cost of the communication system as a whole which uses such an expensive monitoring control apparatus inevitably becomes high.

Because the conventional monitoring and control system which has the redundant structure by use of the plurality of monitoring control apparatuses requires the operator to manually switch from the working monitoring control apparatus to the backup monitoring control apparatus when the working monitoring control apparatus fails, it takes a relatively long time for the operator to recognize the failure of the working monitoring control apparatus, switch the connection to the backup monitoring control apparatus, resume the monitoring and control by the backup monitoring control apparatus, and continue the monitoring and control operation. Consequently, a state in which the communication network is not monitored continues for the relatively long time, thereby causing a delay in detecting a failure which is generated in the communication network during this time, and a long interruption of the control which is necessary with respect to the communication network. Therefore, the interruption and the like of the communication service is generated, and there is a problem in that the communication service deteriorates.

Particularly, it takes a long time to carry out a control operation such as downloading from the monitoring control apparatus data which are necessary to normally operate the monitored control apparatus such as a communication apparatus which forms the communication network. For this reason, such a control operation is often reserved to be carried out at a time during the night when the operator is not present. But when the monitoring control apparatus fails during such a control operation carried out at night, the operator must manually switch the working monitoring control apparatus to the backup monitoring control apparatus the next morning. Consequently, the failure of the working monitoring control apparatus cannot be corrected quickly, and there is a problem in that it is difficult to provide a stable communication service particularly during busy hours.

SUMMARY OF THE INVENTION

Accordingly, it is a general object of the present invention to provide a novel and useful redundant monitoring control system, monitoring control apparatus therefor and monitored control apparatus, in which the problems described above are eliminated.

Another and more specific object of the present invention is to provide a redundant monitoring control system, monitoring control apparatus therefor and monitored control apparatus, which can automatically switch from a working monitoring control apparatus to a backup monitoring control apparatus when a failure is generated in the working monitoring control apparatus and continue the monitoring and control operation, without the need for an operator to manually carry out such operations.

Still another object of the present invention is to provide a redundant monitoring control system comprising at least one monitored control apparatus forming a communication network, a plurality of monitoring control apparatuses monitoring and controlling the monitored control apparatus, means, provided in the monitored control apparatus, for switching a monitoring and control of the monitored control apparatus by a monitoring control apparatus of a working system to a monitoring control apparatus of a backup system in response to a disconnection from the monitoring control apparatus of the working system which is detected when the monitoring control apparatus of the working system fails, and means, provided in the monitoring control apparatus of the backup system, for recognizing a control operation carried out by the monitoring control apparatus of the working system until the switching, and carrying out a remainder of the recognized control operation with respect to the monitored control apparatus. According to the redundant monitoring control system of the present invention, the control information is transferred to one of the monitoring control apparatuses which form a redundant structure, in response to the generation of the failure in the monitoring control apparatus of the working system. In addition, the monitoring and control of the monitored control apparatus is taken over by the monitoring control apparatus of the backup system. As a result, it is possible to continue the monitoring and control of the monitored control apparatus even when the monitoring control apparatus of the working system fails, without requiring a manual operation of the maintenance operator.

The redundant monitoring control system may further comprise means, provided in the monitored control apparatus, for establishing a connection to the monitoring control apparatus of the backup system when the disconnection to the monitoring control apparatus of the working system is detected, and means, provided in the monitored control apparatus, for notifying the control operation carried out by the monitoring control apparatus of the working system until the failure to the monitoring control apparatus of the backup system.

The redundant monitoring control system may further comprise means, provided in the monitoring control apparatus of the backup system, for establishing a connection to the monitoring control apparatus of the working system and successively acquiring monitored information and control information related to the monitored control apparatus from the monitoring control apparatus of the working system, and means, provided in the monitoring control apparatus of the backup system, for monitoring a state of the monitoring control apparatus of the working system, and when a failure of the monitoring control apparatus of the working system is detected, establishing a connection with respect to the monitored control apparatus and taking over the control operation carried out by the monitoring control apparatus of the working system until the failure.

In the redundant monitoring control system, the plurality of monitoring control apparatuses which are provided with respect to each monitored control apparatus may be grouped to distribute load of processing with respect to each monitored control apparatus.

A further object of the present invention is to provide a monitored control apparatus which establishes a connection to a monitoring control apparatus of a working system and is monitored and controlled by the monitoring control apparatus of the working system, comprising means for establishing a connection to a monitoring control apparatus of a backup system when a disconnection of the connection to the monitoring control apparatus of the working system is detected, and means for notifying to the monitoring control apparatus of the backup system a control operation carried out by the monitoring control apparatus of the working system until the disconnection, so that monitoring and control of the monitored control apparatus are taken over by the monitoring control apparatus of the backup system after the disconnection.

Another object of the present invention is to provide a monitoring control apparatus for monitoring and controlling a monitored control apparatus via a connection which is established between the monitoring control apparatus and the monitored control apparatus, comprising means for receiving control information which is related to control carried out by an other monitoring control apparatus and is notified from the monitored control apparatus, and means for taking over the control carried out by the other monitoring control apparatus based on the control information.

Still another object of the present invention is to provide a monitoring control apparatus for monitoring and controlling a monitored control apparatus via a connection which is established between the monitoring control apparatus and the monitored control apparatus, comprising means for successively notifying monitored information and control information related to the monitored control apparatus to an other monitoring control apparatus of a backup system when the monitoring control apparatus operates as a working system, and means for taking over a control operation carried out by an other monitoring control apparatus of a working system with respect to the monitored control apparatus based on control information notified from the other monitoring control apparatus of the working system when the monitoring control apparatus operates as a backup system and a disconnection of the monitoring control apparatus from the other monitoring control apparatus of the working system is detected.

The monitoring control apparatus may be grouped with a plurality of monitoring control apparatuses which are provided with respect to the monitored control apparatus so as to distribute load of processing with respect to the monitored control apparatus.

Other objects and further features of the present invention will be apparent from the following detailed description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a timing diagram for explaining the working system switching in a first embodiment of the present invention;

FIG. **2** is a functional block diagram showing a monitoring control section of a monitored control apparatus according to the present invention;

FIG. **3** is a system block diagram showing a mobile communication system applied with the present invention;

FIG. **4** is a functional block diagram showing a base station controller of the present invention;

FIG. **5** is a functional block diagram showing an operation and maintenance center radio according to the present invention;

FIG. **6** is a diagram for explaining the IP address which is held in the operation and maintenance center radio and the base station controller in the first embodiment of the present invention;

FIG. **7** is timing diagram for explaining the operation sequence of the first embodiment of the present invention;

FIG. 8 is a timing diagram for explaining the operation sequence of the first embodiment of the present invention;

FIG. 9 is a diagram for explaining the IP address which is held in the operation and maintenance center radio and the base station controller in a second embodiment of the present invention;

FIG. 10 is a timing diagram for explaining the operation sequence of the second embodiment of the present invention;

FIG. 11 is a timing diagram for explaining the operation sequence of the second embodiment of the present invention;

FIG. 12 is a system block diagram showing the system structure of a third embodiment of the present invention;

FIG. 13 is a timing diagram for explaining the operation sequence of the third embodiment of the present invention;

FIG. 14 is a timing diagram for explaining the operation sequence of the third embodiment of the present invention;

FIG. 15 is a diagram for explaining the corresponding relationship of the working system and the backup system of the operation and maintenance center radio in the third embodiment of the present invention;

FIG. 16 is a diagram for explaining the IP addresses which are held in the operation and maintenance center radio in the third embodiment of the present invention; and

FIG. 17 is a diagram for explaining the IP addresses which are held in the base station controller in the third embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a timing diagram for explaining the working system switching in a first embodiment of the present invention. For the sake of convenience, it is assumed that monitoring control information is exchanged via a network between a monitoring control apparatus 12_0 of a working (or active) system #0 and a monitored control apparatus 11. Control information is transmitted from the monitoring control apparatus 12_0 of the working system #0 to the monitored control apparatus 11, and state information of the monitored control apparatus 11 is notified from the monitored control apparatus 11 to the monitoring control apparatus 12_0 of the working system #0.

More particularly, as shown in FIG. 1, a step (1-1) transmits a monitoring information read instruction from the monitoring control apparatus 12_0 of the working system #0, and a step (1-2) transmits monitored information from the monitored control apparatus 11. In addition, steps (1-3), (1-5), . . . transmit control instructions from the monitoring control apparatus 12_0 of the working system #0, and steps (1-4), (1-6), . . . transmit control responses from the monitored control apparatus 11 in response to the transmit control instructions.

Hence, an operator can remotely monitor the state of the monitored control apparatus 11 in the communication network using the monitoring control apparatus 12_0 of the working system #0, and monitor and control the state of the monitored control apparatus 11 by sending control instructions for controlling the operation and the like of the monitored control apparatus 11. As a result, it is possible to provide a stable communication service.

If a failure is generated in the monitoring control apparatus 12_0 of the working system #0 in a step (1-7) and it becomes impossible to communicate between the monitoring control apparatus 12_0 and the monitored control apparatus 11, the monitored control apparatus 11 detects in a step (1-8) that the communication between the monitored control apparatus 11 and the monitoring control apparatus 12_0 of the working system #0 is disconnected.

In the monitored control apparatus 11, an address of a monitoring control apparatus 12_1 of a backup (or standby) system #1 is set in advance together with an address of the monitoring control apparatus 12_0 of the working system #0. Hence, when the disconnection of the communication between the monitored control apparatus 11 and the monitoring control apparatus 12_0 of the working system #0 is detected, the step (1-8) switches the address to which the monitored control apparatus 11 is connected by referring to the set addresses.

Based on the switched address to which the monitored control apparatus 11 is connected, the monitored control apparatus 11 makes a connection to the monitoring control apparatus 12_1 of the backup system #1 in a step (1-9). When a communication between the monitored control apparatus 11 and the monitoring control apparatus 12_1 of the backup system #1 is established in a step (1-10), the monitoring control apparatus 12_1 of the backup system #1 transmits a monitoring information read instruction to the monitored control apparatus 11 in a step (1-11), and transmits a control information read instruction to the monitored control apparatus 11 in a step (1-13).

With respect to the monitored information read instruction, the monitored control apparatus 11 transmits the monitored information to the monitoring control apparatus 12_1 of the backup system #1 in a step (1-12). In addition, with respect to the control information read instruction, the monitored control apparatus 11 transmits to the monitoring control apparatus 12_1 of the backup system #1, together with a response thereto, contents of the control carried out by the monitoring control apparatus 12_0 of the working system #0 up to that time, in a step (1-14).

Based on the control information transmitted from the monitored control apparatus 11, the monitoring control apparatus 12_1 of the backup system #1 judges whether or not a control operation is interrupted by the generation of the failure. If an interrupted control operation exists, the monitoring control apparatus 12_1 of the backup system #1 continues the interrupted control operation in steps (1-15), (1-17), ... With respect to the control operation which is continued by the monitoring control apparatus 12_1 of the backup system #1, the monitored control apparatus 11 transmits a response similarly to the response with respect to the monitoring control apparatus 12_0 of the working system #0, in steps (1-16), (1-18), ...

In the particular case shown in FIG. 1, the failure is generated when the monitoring control apparatus 12_0 of the working system #0 transmits up to the second control instruction of the n control instructions. Hence, the monitoring control apparatus 12_1 of the backup system #1 continues the control operation by taking over the control operation after the failure is generated, that is, taking over the transmission of the second and subsequent control instructions. In FIG. 1, (1/n), (2/n), . . . indicate the first, second, . . . of the n control instructions or the n control responses.

Therefore, when the failure is generated in the monitoring control apparatus of the working system, the system is switched to the monitoring control apparatus of the backup system. Hence, the monitoring and control operation is taken over by the monitoring control apparatus of the backup system from the monitoring control apparatus of the work-

ing system, and the monitored control apparatus, that is, each communication apparatus in the communication network, is monitored and controlled without interruption.

FIG. 2 is a functional block diagram showing a monitoring control section of a monitored control apparatus according to the present invention. Normally, a monitored control apparatus 21 such as a communication apparatus which forms a communication network, is provided with a monitoring control section 22 which monitors and controls the state of the monitored control apparatus 21 to which this monitoring control section 22 belongs. The monitoring control section 22 includes a state management function 23, a to-monitoring control apparatus interface termination function 24, and a control execution function 25.

The state management function 23 manages the states of each of the parts within the monitored control apparatus 21, and notifies state information to the to-monitoring control apparatus interface termination function 24. The to-monitoring control apparatus interface termination function 24 notifies the state information to a monitoring control apparatus 27 of the working system, and notifies a control instruction to the control execution function 25 in response to the control instruction from the monitoring control apparatus 27 of the working system.

In addition, the to-monitoring control apparatus interface termination function 24 monitors whether the communication between the monitored control apparatus 21 and the monitoring control apparatus 27 of the working system is normal or abnormal. In addition, in order to communicate with a plurality of control apparatuses including a monitoring control apparatus 28 of the backup system, the to-monitoring control apparatus interface termination function 24 holds addresses of the plurality of monitoring control apparatuses.

The control execution function 25 receives the control instruction from the monitoring control apparatus 27 of the working system via the to-monitoring control apparatus interface termination function 24, and controls the operations and states of each of the parts within the monitored control apparatus 21.

In this first embodiment of the present invention described above, the control management function 26 which includes a storage unit is provided within the monitoring control section 22 of the monitored control apparatus 21, and the control instruction from the monitoring control apparatus 27 of the working system is successively stored in the storage unit. The stored contents are notified to the monitoring control apparatus 28 of the backup system in response to a control information read request which is received from the monitoring control apparatus 28 of the backup system via the to-monitoring control apparatus interface termination function 24.

The monitoring control apparatus 28 of the backup system makes the control information read request with respect to the monitored control apparatus 21 when connected to the monitored control apparatus 21. The control information includes information related to the type of control instructed from the monitoring control apparatus 27 of the working system, whether or not the control is completed or in progress, and if in progress which part of the control has been carried out.

The monitored control apparatus 21 notifies the control information which is stored in the control management function 26 to the monitoring control apparatus 28 of the backup system via the to-monitoring control apparatus interface termination function 24. The monitoring control apparatus 28 of the backup system recognizes the contents of the control carried out by the monitoring control apparatus 27 of the working system up to the time immediately before receiving the notification.

The monitoring control apparatus 28 of the backup system takes over and continues the control carried out by the monitoring control apparatus 27 of the working system, via a connection which is established between the monitoring control apparatus 28 of the backup system and the monitored control apparatus 21.

The to-monitoring control apparatus interface termination function 24 holds an address (ADDRESS_ACT) of the monitoring control apparatus 27 of the working system which is presently connected, and an address (ADDRESS_SBY) of the monitoring control apparatus 28 of the backup system.

When the to-monitoring control apparatus interface termination function 24 detects the disconnection of the connection between the monitored control apparatus 21 and the monitoring control apparatus 27 of the working system, the to-monitoring control apparatus interface termination function 24 switches the connecting address from the address of the monitoring control apparatus 27 of the working system to the address of the monitoring control apparatus 28 of the backup system, so as to establish a connection to the monitoring control apparatus 28 of the backup system. The to-monitoring control apparatus interface termination function 24 transmits the monitored information and the control information described above in response to the control information read request from the monitoring control apparatus 28 of the backup system.

Next, a description will be given of a second embodiment of the present invention. In the first embodiment described above, the control management function 26 is provided within the monitored control apparatus 21, the control information from the monitoring control apparatus 27 of the working system is stored by the control management function 26, and the stored contents are notified to the monitoring control apparatus 28 of the backup system so as to transfer the control information to the monitoring control apparatus 28 of the backup system. However, it is possible to transfer the control information by constantly notifying the control information from the monitoring control apparatus 27 of the working system to the monitoring control apparatus 28 of the backup system.

In other words, in this second embodiment of the present invention, the monitoring control apparatus 27 of the working system transmits a control instruction to the monitored control apparatus 21, and also transmits the same control instruction to the monitoring control apparatus 28 of the backup system. The monitoring control apparatus 28 of the backup system constantly receives the control instruction from the monitoring control apparatus 27 of the working system, and similarly to the control management function 26 described above, the monitoring control apparatus 28 of the backup system includes the functions of storing a history of the control information which includes information related to the type of control instructed from the monitoring control apparatus 27 of the working system, whether or not the control is completed or in progress, and if in progress which part of the control has been carried out.

In addition, the monitoring control apparatus 28 of the backup system holds an address (ADDRESS_MANAGED) of the monitored control apparatus 21 in addition to the address (ADDRESS_ACT) of the monitoring control apparatus 27 of the working system.

Normally, when a failure is generated in the monitoring control apparatus **27** of the working system and the connection between the monitoring control apparatus **27** of the working system and the monitored control apparatus **21** becomes disconnected, the connection between the monitoring control apparatus **27** of the working system and the monitoring control apparatus **28** of the backup system also becomes disconnected.

The monitoring control apparatus **28** of the backup system recognizes that the connection to the monitoring control apparatus **27** of the working system is disconnected, and establishes a connection to the monitored control apparatus **21** in response to this recognition. Thus, similarly to the first embodiment described above, the monitoring control apparatus **28** of the backup system takes over the control carried out by the monitoring control apparatus **27** of the working system. As a result, the monitored control apparatus **21** is automatically restored to the normal monitored state, and is monitored by the monitoring control apparatus **28** of the backup system.

Next, a description will be given of embodiments which are applied with the working system switching of the present invention. FIG. **3** is a system block diagram showing a mobile communication system applied with the present invention. In FIG. **3**, a radio station maintenance and operation apparatuses (hereinafter referred to as an Operation and Maintenance Center Radios or simply OMCRs) $\mathbf{31}_1$ and $\mathbf{31}_2$ respectively correspond to the monitoring control apparatus described above, and a plurality of Base Station Controllers (BSCs) $\mathbf{32}_1$ through $\mathbf{32}_2$ respectively correspond to the monitored control apparatus described above. The OMCRs $\mathbf{31}_1$and $\mathbf{31}_2$ remotely collect state information of each apparatus, with respect to the BSCs $\mathbf{32}_1$ through $\mathbf{32}_n$ and apparatuses which serve under the BSCs $\mathbf{32}_1$ through $\mathbf{32}_n$. The OMCRs $\mathbf{31}_1$ and $\mathbf{31}_2$ also control the operation or state of such apparatuses.

The BSCs $\mathbf{32}_1$ through $\mathbf{32}_n$ and the OMCRs $\mathbf{31}_1$ and $\mathbf{31}_2$ are connected via a Local Area Network (LAN) **33**, and exchange monitored information and the control information using a TCP/IP-based protocol.

In order to exchange the above information on the LAN **33**, it is a condition that a TCP connection is established. Equipments connected to the LAN **33** each have an individual IP address assigned thereto, and each equipment holds an IP address of each communication destination in order to establish the TCP connection.

The BSCs $\mathbf{32}_1$ through $\mathbf{32}_n$ respectively manage the state thereof and the state of each Base station Transceiver Subsystem (BTS) **34** which serves thereunder. The BSCs $\mathbf{32}_1$ through $\mathbf{32}_n$ have the function of notifying such state information to the OMCRs $\mathbf{31}_1$ and $\mathbf{31}_2$ independently or, in response to requests from the OMCRs $\mathbf{31}_1$ and $\mathbf{31}_2$.

The BTS **34** transmits communication information between a Mobile Station (MS) **35** via a radio channel, and relays the communication information to a Mobile Switching Center (MSC) **36** via the BSCs $\mathbf{32}_1$ through $\mathbf{32}_n$.

FIG. **4** is a functional block diagram showing the base station controller (BSC) of the present invention. A BSC **40** shown in FIG. **4** includes an audio signal processor **401** for processing audio signals to and from a BTS, an ATM cell switch **402**, an audio signal processor **403** for processing audio signals to and from a switching system, a switching system interface **404**, an Order Wire (OW) processor **405**, an InterWorking Function (IWF) interface **406**, a time reference generator **407**, a reference signal distributor **408**, and a monitoring controller **410**.

The monitoring controller **410** includes an OMCR interface **411**, a state manager **412**, and a control execution manager **413**. The OMCR interface **411** has the functions of establishing a communication between the BSC **40** and an OMCR $\mathbf{42}_1$ or $\mathbf{42}_2$, and detecting a disconnection of the communication.

The state manager **412** has the function of collecting and managing state information of the parts within the BSC **40** and each apparatus such as the BTS which serves under the BSC **40**. In addition, the state manager **412** has the function of notifying the state information to the OMCR $\mathbf{42}_1$ or $\mathbf{42}_2$ independently or, in response to a request from the OMCR $\mathbf{42}_1$ or $\mathbf{42}_2$.

The control execution manager **413** has the functions of controlling the parts within the BSC **40** and each apparatus such as the BTS which serves under the BSC **40**, based on a control instruction from the OMCR $\mathbf{42}_1$ or $\mathbf{42}_2$, and managing control states of the parts within the BSC **40** and each apparatus such as the BTS.

FIG. **5** is a functional block diagram showing the operation and maintenance center radio (OMCR) according to the present invention. An OMCR **50** shown in FIG. **5** includes a LAN interface termination processor **51**, an application interface termination processor **52**, a monitoring and control information processor **53**, a storage unit **54**, and a display/operation controller **55**.

The LAN interface termination processor **51** has the functions of establishing a communication between the OMCR **50** and the BSC, and detecting a disconnection of the communication. The application interface termination processor **52** has the function of terminating the state information and the control information exchanged between the BSC and the monitoring control information processor **53**.

The monitoring control processor **53** stores information collected from the monitored control apparatus into the storage unit **54**, and carries out a process of transferring a control instruction from a maintenance operator to the monitored control apparatus. The display/operation controller **55** has the functions of displaying the information collected from the monitored control apparatus, identifying a control instruction operation and the like from the maintenance operator, and notifying the information to the monitoring and control processor **53**.

Next, a description will be given of the switching of the working system in the first embodiment of the present invention by the OMCR and the BSC having the functional blocks described above.

As shown in FIG. **6**, OMCRs OMCR1 and OMCR2 and BSCs BSC1 through BSCn each hold an IP address thereof and an IP address of each communication destination, that is, the IP address of each party to which the connection is to be made. Priorities #1 and #2 are assigned to the IP addresses of the OMCRs OMCR1 and OMCR2 which are held by the BSCs BSC1 through BSCn which are monitored controlled apparatuses.

For the sake of convenience, it is assumed that the first OMCR OMCR1 operates as monitoring control apparatus of the working system, a TCP connection is established between the first OMCR OMCR1 and each BSC, and the first OMCR OMCR1 monitors and controls each BSC. Further, it is assumed that the second OMCR OMCR2 operates as the monitoring control apparatus of the backup system, and no TCP connection is established between the second OMCR OMCR2 and each BSC, and no direct exchange of information is made between the second OMCR OMCR2 and each BSC.

If the maintenance operator carries out an operation to download station data for the BTS to the BSC, the downloaded data are divided into packets respectively having a predetermined fixed length and transferred to each BSC from the first OMCR OMCR1.

FIGS. **7** and **8** are timing diagrams for explaining the operation sequence of the first embodiment of the present invention. As shown in FIG. **7**, a first OMCR 71, (OMCR1) carries out a connection establishing process to establish a connection between the first OMCR $\mathbf{71}_1$ and each of BSCs $\mathbf{72}_1$ through $\mathbf{72}_n$ (BSC1 through BSCn) in a step **(7-1)**, and carries out a state collecting process to collect state information of each of the BSCs $\mathbf{72}_1$ through $\mathbf{72}_n$ in a step **(7-2)**.

The operator of the first OMCR $\mathbf{71}_1$ transmits a download control instruction to the BSC $\mathbf{72}_1$ in a step **(7-3)**. The first OMCR $\mathbf{71}_1$ makes a download start request to the BSC **72**, in a step **(7-4)**, and the BSC $\mathbf{72}_1$ makes a download start response to the first OMCR $\mathbf{71}_1$ in a step **(7-5)**.

It is assumed that the size of the station data for the BTS is such that the station data can be transferred by a total of fifty-seven packets. The first OMCR $\mathbf{71}_1$ transmits information which indicates the total number of packets to be transferred and a position of each packet which is being transferred within the total number of packets, together with the downloaded data, to the BSC $\mathbf{72}_1$ in a step **(7-6)**.

The BSC $\mathbf{72}_1$ writes the downloaded data into a memory in a step **(7-7)**, and returns a downloaded data response to the first OMCR $\mathbf{71}_1$ in a step **(7-8)**.

If up to twenty-two packets are transmitted in a step **(7-9)**, and a failure is generated in the first OMCR $\mathbf{71}_1$ in a step **(7-10)**, the BSCs $\mathbf{72}_1$ through $\mathbf{72}_n$ detect the disconnection of the TCP connection to the first OMCR $\mathbf{71}_1$ in a step **(7-11)**.

The BSCs $\mathbf{72}_1$ through $\mathbf{72}_n$ switch the IP address of the connecting destination from the IP address of the first OMCR $\mathbf{71}_1$ of the working system to the IP address of a second OMCR 712 (OMCR2) of the backup system, and establishes a connection to the second OMCR $\mathbf{71}_2$ of the backup system in a step **(8-12)** shown in FIG. **8**.

When the TCP connections are established between the BSCs $\mathbf{72}_1$ through $\mathbf{72}_n$ and the second OMCR $\mathbf{71}_2$ of the backup system, the second OMCR $\mathbf{71}_2$ of the backup system transmits a control information read request to each of the BSCs $\mathbf{72}_1$ through $\mathbf{72}_n$ in a step **(8-13)**. Further, the second OMCR $\mathbf{71}_2$ acquires the type of control (that is, control type) previously carried out by the first OMCR $\mathbf{71}_1$ of the working system with respect to each of the BSCs $\mathbf{72}_1$ through $\mathbf{72}_n$ and the control state of each of the BSCs $\mathbf{72}_1$ through $\mathbf{72}_n$ in a step **(8-14)**.

The control information transmitted from each of the BSCs $\mathbf{72}_1$ through $\mathbf{72}_1$ to the second OMCR $\mathbf{71}_2$ Of the backup system includes the following items.

① Control Type: Down load control of station data for the BTS to the BSC; and

② Control State: Incomplete (Transferring twenty-second packet **(22/57)** of the total of fifty-seven packets).

Based on the control information notified from the BSC $\mathbf{72}_1$, the second OMCR $\mathbf{71}_2$ of the backup system resumes the item ①, "down load control of station data for the BTS to the BSC", from the twenty-second packet in a step **(8-15)**.

The BSC $\mathbf{72}_1$ writes the downloaded data from the twenty-second packet transmitted from the second OMCR $\mathbf{71}_2$ of the backup system into the memory, similarly to the above, in a step **(8-16)**. The BSC $\mathbf{72}_1$ continues to receive the downloaded data subsequent to the twenty-second packet and up to the last packet from the second OMCR $\mathbf{71}_2$ of the backup system in a step **(8-17)**, and the BSC $\mathbf{72}_1$ carries out a download end process in a step **(8-18)**. The BSC $\mathbf{72}_1$ notifies a download end with respect to the second OMCR $\mathbf{71}_2$ of the backup system in a step **(8-19)**. The BSCs $\mathbf{72}_2$ through $\mathbf{72}_n$ other than the BSC $\mathbf{72}_1$ operates similarly to the BSC $\mathbf{72}_1$.

Next, a description will be given of the switching of the working system in the second embodiment of the present invention. In this embodiment, OMCRs OMCR1 and OMCR2 and BSCs BSC1 through BSCn each hold an IP address thereof and an IP address of each communication destination, that is, the IP address of each party to which the connection is to be made, as shown in FIG. **9**.

Priorities **#1** and **#2** are assigned to the IP addresses of the OMCRs OMCR1 and OMCR2 which are held by the BSCs BSC1 through BSCn. Furthermore, the OMCRs OMCR1 and OMCR2 also hold IP addresses other OMCRs.

FIGS. **10** and **11** are timing diagrams for explaining the operation sequence of the second embodiment of the present invention. For the sake of convenience, it is assumed that a first OMCR $\mathbf{101}_1$ (OMCR1) operates as the monitoring control apparatus of the working system. As shown in FIG. **10**, the first OMCR $\mathbf{101}_1$ (OMCR1) carries out a connection establishing process to establish a connection between the first OMCR $\mathbf{101}_1$ and each of BSCs $\mathbf{102}_1$ through $\mathbf{102}_n$ (BSC1 through BSCn) in a step **(10-2)**, and carries out a state collecting process to collect state information of each of the BSCs $\mathbf{102}_1$ through $\mathbf{102}_n$ in a step **(10-3)**.

A second OMCR $\mathbf{101}_2$ (OMCR2) operates as the monitoring control apparatus of the backup system. No TCP connection is established between the second OMCR $\mathbf{101}_2$ and each of the BSCs $\mathbf{102}_1$ through $\mathbf{102}_n$. However, the second OMCR $\mathbf{101}_2$ establishes a TCP connection between the first OMCR $\mathbf{101}_1$ in a step **(10-1)**, and information is exchanged between the first and second OMCRs $\mathbf{101}_1$ and $\mathbf{101}_2$ in a step **(10-4)**.

In other words, the second OMCR $\mathbf{101}_2$ can exchange information with each of the BSCs $\mathbf{102}_1$ through $\mathbf{102}_1$ via the first OMCR $\mathbf{101}_1$, and the second OMCR $\mathbf{101}_2$ can be constructed to provide the same functions as the first OMCR $\mathbf{101}_1$ to the maintenance operator.

If the maintenance operator carries out an operation to download station data for the BTS to the BSC $\mathbf{101}_1$ in a step **(10-5)**, the first OMCR $\mathbf{101}_1$ transmits a download start request to the BSC $\mathbf{102}_1$ in a step **(10-6)**, and the BSC $\mathbf{102}_1$ makes a download start response to the first OMCR $\mathbf{101}_1$ in a step **(10-7)**.

The downloaded data are divided into packets having a predetermined fixed length, and transferred from the first OMCR $\mathbf{101}_1$ to the BSC $\mathbf{102}_1$. It is assumed that the size of the station data for the BTS is such that the station data can be transferred by a total of fifty-seven packets.

The first OMCR $\mathbf{101}_1$ transmits information which indicates the total number of packets to be transferred and a position of each packet which is being transferred within the total number of packets, together with the downloaded data, to the BSC $\mathbf{102}_1$ in a step **(10-8)**. At the same time, the first OMCR $\mathbf{101}_1$ transmits similar information to the second OMCR $\mathbf{1012}_1$ in steps **(10-9)** through **(10-11)**.

The BSC $\mathbf{102}_1$ writes the downloaded data into a memory in a step **(10-12)**, and returns a downloaded data response to the first OMCR $\mathbf{101}_1$ in a step **(10-13)**. The first OMCR $\mathbf{101}_1$ transmits the same data to the second OMCR $\mathbf{101}_2$ of the backup system in a step **(10-14)**.

If up to twenty-two packets are transmitted in a step **(10-15)**, and a failure is generated in the first OMCR $\mathbf{101}_1$

in a step (10-16), the BSC 102_1 detects the disconnection of the TCP connection to the first OMCR 101_1, and switches the IP address of the connecting destination from the IP address of the first OMCR 101_1 of the working system to the IP address of the second OMCR 101_2 of the backup system, in a step (10-17).

The other BSCs 102_2 through 102_1 similarly switch the IP address of the connecting destination from the IP address of the first OMCR 101_1 of the working system to the IP address of the second OMCR 101_2 of the backup system, in a step (10-17).

At the same time, the TCP connection between the first and second OMCRs 101_1 and 101_2 is also disconnected. Hence, the second OMCR 101_2 detects the disconnection of the TCP connection to the first OMCR 101_1, and the second OMCR 101_2 switches the connecting destination from the first OMCR 101_1 to each of the BSCs 102_1 through 102_1 by referring to the table of IP addresses shown in FIG. 9, in a step (10-18). In addition, the second OMCR 101_2 establishes connections to the BSCs 102_1 through 102_n in a step (11-19) shown in FIG. 11.

When the TCP connections are established between the BSCs 102_1 through 102_1 and the second OMCR 101_2 of the backup system, the second OMCR 101_2 of the backup system continues to transmit the downloaded data from the twenty-second packet with respect to the BSC 102_1 by taking over the operation from the first OMCR 101_1, in a step (11-20). The operation carried out thereafter is the same as that of the first embodiment described above.

FIG. 12 is a system block diagram showing the system structure of a third embodiment of the present invention. This third embodiment of the present invention is provided with a plurality of BSCs 122_1 through 122_4 (BSC1 through BSC4) which are to be monitored, and a plurality of OMCRs 121_1 through 121_4 (OMCR1 through OMCR4) which establish TCP connections and exchange information directly, so as to distribute the load of the processing in the OMCR. In FIG. 12, dotted lines with arrows indicate the flow of information.

In FIG. 12, the first OMCR 121_1 establishes TCP connections with the first and second BSCs 122_1 and 122_2, and monitors the first and second BSCs 122_1 and 122_2.

The second OMCR 121_2 establishes a TCP connection with the first OMCR 121_1, and holds the same information as the first OMCR 121_1.

When a failure is generated in the first OMCR 121_1, the second OMCR 121_2 takes over the control operation of the first OMCR 121_1, similarly to the second embodiment described above.

Similarly, the third OMCR 121_3 establishes TCP connections with the third and fourth BSCs 122_3 and 122_4, and monitors the third and fourth BSCs 122_3 and 122_4.

The fourth OMCR 121_4 establishes a TCP connection with the third OMCR 121_3, and holds the same information as the third OMCR 121_3.

When a failure is generated in the third OMCR 121_3, the fourth OMCR 121_4 takes over the control operation of the third OMCR 121_3, similarly to the second embodiment described above.

Although only four OMCRs are shown in FIG. 12_1 it is of course possible to provide more than four OMCRs. In addition, the OMCR of the working system directly exchanges the information with the BSC, and four OMCRs are provided in FIG. 12 to distribute the load of the processing. Hence, it is of course possible to provide only one OMCR as in the second embodiment described above or, to provide three or more OMCRs.

FIGS. 13 and 14 are timing diagrams for explaining the operation sequence of the third embodiment of the present invention. In FIG. 13, a TCP connection is established between the first OMCR 131_1 and the second OMCR 131_2 in a step (13-1), and a TCP connection is established between the third OMCR 131_3 and the fourth OMCR 131_4 in a step (13-2).

For the sake of convenience, it is assumed that the first OMCR 131_1 is the monitoring control apparatus of the working system. A TCP connection is established between the first and second BSCs 132_1 and 132_2 in a step (13-3). State collecting processes are carried out from the first and second BSCs 132_1 and 132_2, and the state information is notified to the second OMCR 131_2 in a step (13-5).

For the sake of convenience, it is assumed that the third OMCR 131_3 is the monitoring control apparatus of the working system. A TCP connection is established between the third and fourth BSCs 132_3 and 132_4 in a step (13-4). State collecting processes are carried out from the third and fourth BSCs 132_3 and 132_4, and the state information is notified to the fourth OMCR 131_4 in a step (13-6).

If the maintenance operator carries out an operation to download station data for the BTS to the first BSC 132_1 in a step (13-7), the first OMCR 131_1 transmits a download start request to the first BSC 132_1 in a step (13-8), and the first BSC 132_1 makes a download start response to the first OMCR 131_1 in a step (13-9).

The downloaded data are divided into packets having a predetermined fixed length, and transferred from the first OMCR 131_1 to the first BSC 132_1. It is assumed that the size of the station data for the BTS is such that the station data can be transferred by a total of fifty-seven packets.

The first OMCR 131_1 transmits information which indicates the total number of packets to be transferred and a position of each packet which is being transferred within the total number of packets, together with the downloaded data, to the first BSC 132_1 in a step (13-10). At the same time, the first MCR 131_1 transmits similar information to the second OMCR 131_{21} in steps (13-11) through (13-13).

The first BSC 132_1 writes the downloaded data into a memory in a step (13-14), and returns a downloaded data response to the first OMCR 131_1 in a step (13-15). The first OMCR 131_1 transmits the same data to the second OMCR 131_2 of the backup system in a step (13-16).

If up to twenty-two packets are transmitted in a step (13-17), and a failure is generated in the first OMCR 131_1 in a step (13-18), the first BSC 132_1 detects the disconnection of the TCP connection to the first OMCR 131_1, and switches the IP address of the connecting destination from the IP address of the first OMCR 131_1 of the working system to the IP address of the second OMCR 131_2 of the backup system, in a step (13-19).

The other second BSC 132_2 similarly switches the IP address of the connecting destination from the IP address of the first OMCR 131_1 of the working system to the IP address of the second OMCR 131_2 of the backup system, in a step (13-19).

At the same time, the TCP connection between the first and second OMCRs 131_1 and 131_2 is also disconnected. Hence, the second OMCR 131_2 detects the disconnection of the TCP connection to the first OMCR 131_1, and the second OMCR 131_2 switches the connecting destination from the first OMCR 131_1 to each of the first and second BSCs 132_1 and 132_2 by referring to the table of IP addresses, in a step (13-20). In addition, the second OMCR 131_2 establishes connections to the first and second BSCs 132_1 and 132_2 in a step (14-21) shown in FIG. 14.

When the TCP connections are established between the first and second BSCs 132_1 and 132_2 and he second OMCR 131_2 of the backup system, the second OMCR 131_2 of the backup system continues to transmit the downloaded data from the twenty-second packet with respect to the first BSC 132_1 by taking over the operation from the first OMCR 131_1, in a step (14-22). The operation carried out thereafter is the same as that of the second embodiment described above.

The third OMCR 131_3 continues to monitor the third and fourth BSCs 132_3 and 132_4 even when a failure is generated in the first OMCR 131_1.

In other words, the first and third OMCRs 131_1 and 131_3 carry out a load distributing process with respect to the BSC, and operate independently of each other, such that one is unaffected by the failure of the other. As a result, the reliability of the system is improved, and the circuit scale of the OMCR can be set to an arbitrary optimum scale.

In the embodiment described above, the first and second BSCs BSC1 and BSC2 are connected to the first OMCR OMCR1, the third and fourth BSCs BSC3 and BSC4 are connected to the third OMCR OMCR3, the second OMCR OMCR2 is used as the backup system for the first OMCR OMCR1, and the fourth OMCR OMCR4 is used as the backup system for the third OMCR OMCR3. However, the corresponding relationships of the working and backup systems are not limited to those of the embodiment.

For example, it is possible to construct the system so that, if both the first and second OMCRs OMCR1 and OMCR2 which monitor and control the first and second BSCs BSC1 and BSC2 fail, the third and fourth OMCRs OMCR3 and OMCR4 operate in place of the first and second OMCRs OMCR1 and OMCR2.

In addition, the monitoring and control of the first and second BSCs BSC1 and BSC2 can be carried out by using the first OMCR OMCR1 as the working system and the third OMCR OMCR3 as the backup system.

Therefore, in the monitoring and control employing the distributed load, the OMCR which is forced to operate in only one system can be appropriately backed up by the OMCR of another working or backup system which is used as a new backup system. Hence, the flexibility and safety or reliability of the system are improved.

Next, a description will be given of a case where the first OMCR OMCR1 which monitors and controls the first and second BSCs BSC1 and BSC2 fails, the second OMCR OMCR2 also fails, and the third and fourth OMCRs OMCR3 and OMCR4 take over the operations of the first and second OMCRs OMCR1 and OMCR2 to monitor and control the first and second BSCs BSC1 and BSC2.

First, the first OMCR OMCR1 is connected to the first and second BSCs BSC1 and BSC2, and carries out the monitoring and control thereof. But when the first OMCR OMCR1 fails, the second OMCR OMCR2 takes over the monitoring and control of the first and second BSCs BSC1 and BSC2.

Second, at the time when the second OMCR OMCR2 becomes the working system, the third OMCR OMCR3 becomes the backup system with respect to the second OMCR OMCR2. The second OMCR OMCR2 starts to transfer the monitored information and the control information exchanged between the second OMCR OMCR2 and the first and second BSCs BSC1 and BSC2 to the third OMCR OMCR3.

Third, if the second OMCR OMCR2 thereafter fails before the failed first OMCR OMCR1 is restored, the third OMCR OMCR3 takes over the monitoring and control operation of the failed second OMCR OMCR2. At this point in time, the third OMCR OMCR3 monitors and controls the first through fourth BSCs BSC1 through BSC4.

The third OMCR OMCR3 is connected to the fourth OMCR OMCR4 which is provided as the backup system for the third OMCR OMCR3. Hence, in addition to the monitored information and the control information exchanged between the third OMCR OMCR3 and the third and fourth BSCs BSC3 and BSC4, the third OMCR OMCR3 transfers the monitored information and the control information exchanged between the third OMCR OMCR3 and the first and second BSCs BSC1 and BSC2 to the fourth OMCR OMCR4.

Fourth, the fourth OMCR OMCR4 is originally provided as the backup system for the third OMCR OMCR3. Hence, if the third OMCR OMCR3 thereafter fails, the fourth OMCR OMCR4 takes over the monitoring and control of the first through fourth BSCs BSC1 through BSC4.

FIG. 15 is a diagram for explaining the corresponding relationship of the working system and the backup system of the operation and maintenance center radio (OMCR) in the third embodiment of the present invention. FIG. 15 shows a transition of the BSCs to be monitored and controlled by each OMCR, in the form of a table.

FIG. 16 is a diagram for explaining the IP addresses which are held in each operation and maintenance center radio (OMCR) in the third embodiment of the present invention. In addition, FIG. 17 is a diagram for explaining the IP addresses which are held in each base station controller (BSC) in the third embodiment of the present invention.

In the third embodiment described above, it is assumed that the failure is generated starting from the first and second OMCRs OMCR1 and OMCR2 which monitor and control the first and second BSCs BSC1 and BSC2. However, if the failure is generated in the third OMCR OMCR3 which monitors and controls the third and fourth BSCs BSC3 and BSC4, the control is successively taken over by the fourth OMCR OMCR4, the first OMCR OMCR1, and the second OMCR OMCR2, in this order.

In the embodiment described above, the present invention is applied to the monitoring control system employing the redundant structure which includes the monitoring control apparatuses in the working and backup systems. However, the present invention is of course applicable to a monitoring control system having a structure in which the monitoring control apparatuses are provided in N working systems and one backup system, where N is an integer greater than or equal to one.

Therefore, according to the present invention, the control information is transferred to one of the monitoring control apparatuses which form a redundant structure, in response to the generation of the failure in the monitoring control apparatus of the working system. In addition, the monitoring and control of the monitored control apparatus is taken over by the monitoring control apparatus of the backup system. As a result, it is possible to continue the monitoring and control of the monitored control apparatus even when the monitoring control apparatus of the working system fails, without requiring a manual operation of the maintenance operator.

Accordingly, the reliability of the monitoring control apparatus is improved according to the present invention. For example, it is possible to avoid undesirable situations where a fault is generated in the monitoring control apparatus but the failure generated in the communication system is not found and neglected for a long time or, an essential control operation is interrupted during the control. As a result, the present invention can prevent deterioration of the communication service and interruption of the communication service.

Even in a case where a failure is generated in the monitoring control apparatus during a control operation which extends for a relatively long time such as when downloading the station data, it is possible to continue the control operation without interruption, and the monitoring and control by the monitoring control apparatus can be carried out efficiently.

Further, the present invention is not limited to these embodiments, but various variations and modifications may be made without departing from the scope of the present invention.

What is claimed is:

1. A redundant monitoring control system comprising:

at least one monitored control apparatus forming a communication network;

a plurality of monitoring control apparatuses monitoring and controlling the monitored control apparatus;

means, provided mi the monitored control apparatus, for switching a monitoring and controlling of The monitored control apparatus by a monitoring control apparatus of a working system to a monitoring control apparatus of a backup system in response to a disconnection from monitoring control apparatus of the working system which is detected when the monitoring control apparatus of the working system fails;

means, provided in the monitoring control apparatus of the backup system, for recognizing a control operation carried out by the monitoring control apparatus of the working system until the switching, and carrying out a remainder of the recognized control operations with respect to the monitored control apparatus;

means, provided in the monitored control apparatus, for establishing a connection to the monitoring control apparatus of the backup system when the disconnection to the monitoring control apparatus of the working system is detected; and

means, provided in the monitored control apparatus, for notifying the control operation carried out by the monitoring control apparatus of the working system until the failure to the monitoring control apparatus of the backup system.

2. The redundant monitoring control system as claimed in claim 1, wherein the plurality of monitoring control apparatuses which are provided with respect to each monitored control apparatus are grouped to distribute load of processing with respect to each monitored control apparatus.

3. The redundant monitoring control system as claimed in claim 1, comprising:

means, provided in the monitoring control apparatus of the backup system for establishing a connection to the monitoring control apparatus of the working system and successively acquiring monitored information and control information related to the monitored control apparatus from the monitoring control apparatus of the working system; and

means, provided in the monitoring control apparatus of the backup system, for monitoring a state of the monitoring control apparatus of the working system, and when a failure of the monitoring control apparatus of the working system is detected establishing a connection with respect to the monitored control apparatus and taking over the control operation carried out by the monitoring control apparatus of the working system until the failure.

4. A monitoring control apparatus for monitoring and controlling a monitored control apparatus via a connection which is established between the monitoring control apparatus and the monitored control apparatus, comprising: means for receiving control information which is related to control carried out by an other monitoring control apparatus and is notified from the monitored control apparatus; and means for taking over the control carried out by the other monitoring control apparatus based on the notified control information from the monitored control apparatus in response to detection of a disconnection of the other control apparatus by the monitored control apparatus.

5. A monitored control apparatus which establishes a connection to a monitoring control apparatus of a working system and is monitored and controlled by the monitoring control apparatus of the working system, comprising: means, provided in the monitored control apparatus, for switching a monitoring and controlling of the monitored control apparatus by a monitoring control apparatus of the working system to a monitoring control apparatus of a backup system in response to a disconnection from the monitoring control apparatus of the working system; means for establishing a connection to the monitoring control apparatus of the backup system when the disconnection of the connection to the monitoring control apparatus of the working system is detected; and means for notifying to the monitoring control apparatus of the backup system a control operation carried out by the monitoring control apparatus of the working system until the disconnection, so that monitoring and control of the monitored control apparatus may be taken over by the monitoring control apparatus of the backup system after the disconnection.

* * * * *